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PAPERS ON DECIDUOUS FRUITS AND INSECTICIDES.

THE GRAPE-BERRY MOTH.

BY

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AND

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DECIDUOUS FRUIT INSECT INVESTIGATIONS.

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U. S. D. A., B. E. Bul. 116, Part II. Issued December 18, 1912.

PAPERS ON DECIDUOUS FRUIT INSECTS AND INSECTICIDES.

THE GRAPE-BERRY MOTH.

(*Polychrosis viteana* Clem.)

By FRED JOHNSON and A. G. HAMMAR,
Entomological Assistants.

INTRODUCTION.

The grape-berry moth, *Polychrosis viteana* Clem. (Pl. IV), is an insect enemy of the grape of long standing in the vineyards of the Lake Erie Valley. Since the first reports of its serious injury to the grape crop near Hudson, Ohio, in 1868, it has been an almost continual menace to grape production in vineyards located along the shores of Lake Erie from Sandusky in Ohio eastward into Pennsylvania and New York. Most of the data dealing with this insect cover a series of life-history records and field experiments conducted during the seasons from 1907 to 1909, inclusive, in connection with the investigations of the grape rootworm and other insect pests of the grapevine which have been carried on at North East, Pa., by the section of the Bureau of Entomology engaged in deciduous fruit insect investigations under the direction of Mr. A. L. Quaintance.

Before entering into a discussion of the detailed life-history studies and remedial measures, a brief résumé of an historical nature is given, showing the attention this insect has received from earlier entomologists. In treating of its origin and distribution it is pointed out that for many years it was confused with the European grape-berry moth, *Eudemis botrana* Schiff., an insect which is very destructive to the berries of grapes in the vineyards of southern Europe and to which it is closely related and bears a very close resemblance, both in appearance and in the manner in which it attacks the grape.

Earlier entomologists credited the grape-berry moth with having a number of food plants, but the studies of the late Prof. M. V. Slingerland in 1903 and 1904 indicate that several other species of Polychrosis have been confused with *P. viteana*, and that the latter feeds and reproduces only in the berries of grapes, wild and cultivated. His conclusions are borne out by the observations made during this investigation, for in no case has this insect been reared from anything but blossom clusters and berries of the grape.

Those regions where serious outbreaks of this pest have occurred have been recorded and the habits of the insect and the character of injury are described in detail. Since the character of injury to the grape berry by the grape curculio (*Craponius inæqualis* Say) coincides quite closely with that of the grape-berry moth, the work of this insect is described in order that the injury done by these two insects may not be confused.

A description is given of the stages of the insect, those of the larval and adult forms being quoted from the paper on "Some new species of Polychrosis," by Mr. W. D. Kearfott.[1]

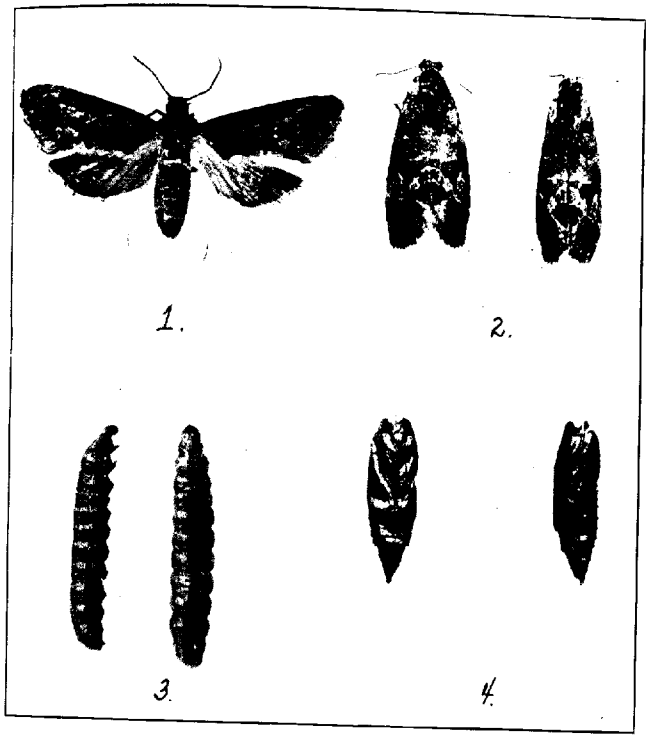
In connection with the rearing experiments it has been found that a large number of hymenopterous parasites prey upon this insect in its larval and pupal stages, and during this investigation 12 additional parasites have been added to the list recorded by Prof. Slingerland in 1904.

During the seasons of 1907 and 1908 the investigation of the grape root-worm occupied the greater part of the time of the force engaged in the study of grape pests. For this reason the life-history studies covering those seasons were rather fragmentary. During the season of 1909, however, the junior author devoted the greater share of his time to a detailed study of the life history of this pest. From the records secured by him in this relation the data covering the various stages of a large number of individuals, presented under the topic of seasonal history for 1909, have been compiled.

These life-history studies indicate that there is only one full brood of larvæ and a partial second brood each season in this region, whereas it was previously supposed that there were two full broods and a partial third brood of larvæ. These records also show the relation of the emergence of the spring brood of moths to the time of blooming of the grape, and the approximate percentage of first-brood larvæ which appear before and after the blooming period, thus indicating the possible relative value of poison-spray applications made against the larvæ before and after the blossoming period.

Field experiments with poison sprays covering several acres of badly infested vineyard were conducted for the three consecutive seasons of 1907, 1908, and 1909, in the vineyard of Mr. W. S. Wheeler, at North East, Pa. These experiments indicate that on account of the extreme variability of infestation of vineyard areas by this pest it is very difficult to lay out an arrangement of plats which will show the relative value of poison-spray applications of varying strength and time of application. Yet there is no doubt that poison-spray applications, made with thoroughness and with due regard to the manner of application, at the time that the larvæ of the first brood

[1] Trans. Amer. Ent. Soc., vol. 30, pp. 292-293, 1904.



THE GRAPE-BERRY MOTH (POLYCHROSIS VITEANA).

FIGS. 1, 2.—ADULT OR MOTH. FIG. 3.—FULL-GROWN LARVÆ. FIG. 4.—PUPÆ. ALL GREATLY ENLARGED. (ORIGINAL.)

are hatching in large numbers, will result in a considerable reduction in the injury wrought to the grape berries by this pest.

Recommendations offered for the control of this insect in regard to the time and manner of making spray applications are based upon the data obtained in the study of the life history and habits of the grape-berry moth during this investigation, correlated with the field experiments and observations covering that period. Since these life-history studies have shown considerable deviations from those previously recorded in regard to the time of appearance of certain stages of the insect and in the number of broods each season, it has been necessary to revise our ideas somewhat as to the relative importance of the spray applications formerly recommended; and since suitable opportunities have not presented themselves for a thorough trial of this revised spray schedule, some of the recommendations along this line are offered rather in the form of suggestions than as definitely demonstrated and proved methods.

HISTORY.

The American species, *Polychrosis viteana*, was first described by Clemens in 1860, in the Proceedings of the Philadelphia Academy of Natural Sciences. In addition to a description of the adult moth Clemens makes some statements as to the habits and food plants of the larva. (See discussion under Food Plants, p. 20.)

In 1869 Packard, in his "Guide to the Study of Insects," has described this insect under the name of *Penthina vitivorana*. In a footnote, however, he states, "It is the *Lobesia botrana* of southern Europe according to Prof. Zeller."

About this date Dr. C. V. Riley sent some specimens of the American-reared species to Mr. P. C. Zeller, of Stettin, Prussia, who identified them as the European species *Lobesia botrana* and Packard's footnote quoted above is doubtless the result of Zeller's identification of the American specimens sent to Europe by Dr. Riley.

From 1870 until 1903 American entomologists accepted the statement of Zeller that the grape-berry moth found in this country was of European origin. In 1903, however, the study of this insect was taken up by Prof. M. V. Slingerland in the vineyards of Chautauqua County, N. Y. Owing chiefly to some variation in the habits of hibernation of the American species from that of the European species—namely, that it makes its overwintering cocoons on fallen leaves, whereas cocoons of the European species are found upon the trellis posts and the trunks of the vines—and since in addition to this the American grape-berry moth is quite common in the fruit of wild grapevines growing at considerable distances from cultivated grapevines, Prof. Slingerland was led to surmise that the American grape-berry moth is a native American species.

In addition to accepting the conclusion of Dr. Riley and Mr. Zeller that the American grape-berry moth is an introduced species, American entomologists previous to Prof. Slingerland's investigations were under the impression that this insect fed and reproduced on several plants other than the grapevine. During his investigation of this insect Prof. Slingerland reared adult moths from many of the plants upon which the grape-berry moth was supposed to feed and in no case was this insect reared from any other plants than from the fruit and blossom clusters of the wild and the cultivated grapevines. Authentic specimens of the European species were secured by him, and these, together with moths reared from other plants and supposed to be the grape-berry moth, were turned over to Mr. W. D. Kearfott for comparison with a large number of American grape-berry moths reared from the fruit of both wild and cultivated grapes.

These comparisons and rearing records made by Mr. Kearfott and Prof. Slingerland have resulted in the former separating the *Polychrosis viteana* of Clemens from the European species and considering it a distinctly native American species feeding and reproducing solely upon the blossom clusters and the fruit of wild and cultivated grapevines. Closely related forms of Polychrosis reared from plants other than the grape have been divided by Kearfott into several new species.

ORIGIN AND DISTRIBUTION.

In regard to the origin of the grape-berry moth, as mentioned under the topic dealing with the history of this insect, American entomologists previous to the investigations of Prof. M. V. Slingerland considered it to have been introduced from Europe. On page 56 of Bulletin No. 223 of the Cornell Agricultural Experiment Station issued during 1904, Slingerland gives several paragraphs under the heading "Comparative notes on the American and European grape-berry moths" which present his views and conclusions on this subject. These are as follows:

COMPARATIVE NOTES ON THE AMERICAN AND EUROPEAN GRAPE-BERRY MOTHS.

In 1860, Clemens (Proc. Acad. Nat. Sci. Phila., p. 369) named some moths *Eudopiza? viteana* which he reared from caterpillars feeding on grape-berries, wild raspberry fruits, and leaves of sassafras. About eight years later, the grape-feeder attained the rank of a serious pest in vineyards, and two other names were suggested for it. Harbison (Prac. Farmer, Nov. and Dec., 1868, p. 170 and 48) called it the grape codling-moth (*Carpocapsa vitisella*) and Packard gave it the name of *Penthina viticoana* (Guide the Study of Insects, p. 336). In 1870, however, Riley sent specimens to Zeller in Prussia, and he said they were identical with the European grape-berry moth (*Eudemis botrana* Schiff.), thus relegating the American names into the synonymy where they have since remained undisturbed. As soon as we found that the insect infesting New York grape-berries was not following the scheduled life-history of the European pest, doubts at once arose regarding the identity of the American

and European grape-berry moths in spite of Zeller's dictum which had stood unquestioned for over thirty years. Several authentic specimens of the European moths were obtained and have been critically compared by an expert, Mr. W. D. Kearfott, with dozens of the moths reared from American grapes, both wild and cultivated, and also with the type specimens of Clemens's *viteana* and some of Riley's material. Briefly stated, the conclusion is that the American grape-berry moth is Clemens's *viteana* which is distinct and easily separable from the European insect. This conclusion, based on a comparison of the moths alone, is strongly supported by our observations on the difference in the life-history of the two insects, and the fact that the American insect freely infests both our wild and cultivated grapes.

The general coloration of the moth of the European insect * * * is an ashy gray with pale grayish hind wings, while the American moths range a trifle smaller, and are of a general purplish-brown color with smoky-brown hind wings. And the large outer marginal patch near the fringe of the front wings affords a sure and easy distinguishing mark between the two insects. In the European *botrana*, the outer edge of this pale olive-green patch is rounded and not indented below, while in the American *viteana* this dark-brown patch is indented above the anal angle by a spur of the lighter ground color of the wing. This characteristic difference is well shown in Fig. 24. There is considerable variation in the indentation of this patch in *viteana* but it is always present; we have a few specimens where the indentation extends through the patch, thus making it smaller and separating off a narrow strip of it on the edge of the wing, but this usually occurs on one wing only, the other being nearly normally indented. Superficially the two insects are marked much alike, but are easily distinguished by the characteristic differences in general coloration and the outer marginal patch. Both species are somewhat variable in size and markings, as shown in Figs. 20 and 24.

An excellent, detailed, 75-page account by G. Del Guercio of the European grape-berry moth was published in 1889 (Nouve Relazioni R. Stazione di Entomologia Agraria di Firenze, Serie Prima, No. I, p. 117–193). In a careful comparison of specimens of the early stages of our American species with Guercio's descriptions, we found but few minor differences.

The bulletin from which this quotation was made also contains descriptions, on pages 57 to 59, of several new species of Polychrosis, by Mr. W. D. Kearfott, under the title "Descriptive notes of some new species of American moths that have been confused with the grape-berry moth." The verdict of Prof. Slingerland that *viteana* is a native American species is now quite generally accepted and has been followed in the preparation of this paper.

According to existing authentic records of its occurrence in North America its distribution is confined to those eastern and west-central States of the United States and to those eastern provinces of Canada in which the growth of wild and improved varieties of American species of grapes is of considerable extent (see fig. 4). For, so far as is known at the present time, this insect confines its depredations entirely to the fruit of native and improved varieties of American species of grapes. It is not known to occur in the vineyards of the Pacific slope and of adjoining States where the grapevines grown are almost entirely of the European or vinifera type.

The States from which the grape-berry moth has been recorded are given in about the order of destructive occurrence of the insect

as follows: Ohio, New York, Pennsylvania, Indiana, Illinois, Michigan, Missouri, New Jersey, Virginia, Maryland, West Virginia, Iowa, Delaware, and Arkansas. It is also reported as occurring in a number of other States in which the production of grapes is very limited, namely, Massachusetts, Connecticut, Kentucky, Kansas, Texas, Nebraska, and Wisconsin. In Canada it is reported from the vicinity of London, Ontario.[1]

FOOD PLANTS.

When Clemens described the American grape-berry moth in 1860 he recorded it as having several food plants and made the following statements concerning the habits of the larva:

The larva feeds on the fruit of the grape in September; a silken gallery is attached to the external opening of the fruit. Its head is dark brownish; shield blackish; body

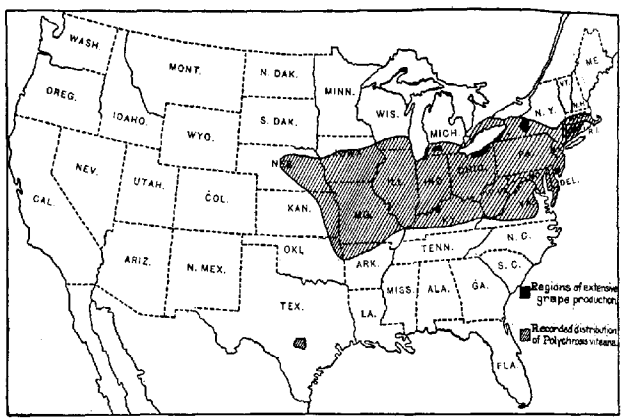


FIG. 4.—Map showing distribution of the grape-berry moth (*Polychrosis viteana*). (Original.)

immaculate dark green. It may likewise be taken on the fruit of wild raspberry. The individual feeding on the grape undergoes transformation by weaving a cocoon on the surface of the ground and that from the raspberry under an excised and turned down portion of leaf. This, however, may not be its normal habit.

Clemens also records it as feeding on leaves of sassafras.

Since that time a number of other entomologists have added several food plants to this list. Packard, in 1868, stated that the first brood feeds on the leaves and tendrils of the grape.

Slingerland gives the following list of food plants added by entomologists during the next thirty years:

Blackberry blossoms (Riley, 1870), roses and *Vernonia* or ironweed (Murtfeldt, 1880 and 1882), tulip-tree leaves and swollen stems of *Amorpha* (Fernald, 1882), flower-buds

[1] SAUNDERS, WM.—Can. Ent., vol. 14, pp. 178-180, 1882.

of common thistle (Coquillett, 1883), berries of wild grapes (Bruner, 1895), grape tendrils and blossoms, seed bunches of sumac, leaves of magnolia, phyllóxera lice and their galls (Marlatt, 1896), and moths bred from flower heads of thoroughwort or boneset and *Ambrosia trifida* have been classed with the grape-berry moth in collections.

In all of the rearings of allied moths made by Kearfott and Slingerland, *viteana* was not obtained from any plants other than the grape. This is also true of the rearings made at North East, Pa., during the investigations of grape insect pests which have been conducted there from 1907 to 1911 by the Bureau of Entomology. It is therefore reasonably safe to state that this insect confined its feeding and reproduction to the blossom clusters and berries of the wild and the cultivated grape.

Mr. Kearfott prefaces his paper[1] with the following statement:

> The following notes are from breeding records extending over the past four years, which have convinced me that each of the species described, as well as a number of others waiting for better material, completes its entire yearly cycle of two or three broods on a single food-plant and also with little doubt each food-plant supports a separate and distinct species. This does not seem unreasonable, for in Europe there are twenty described species of the genus *Polychrosis*.

OCCURRENCE OF THE GRAPE-BERRY MOTH IN DESTRUCTIVE NUMBERS.

The earliest record of serious injury by the grape-berry moth in America is from Mr. M. C. Read, of Hudson, Ohio, in 1869. He states that during that season and for several seasons preceding this date this insect had been very injurious to grapes in vineyards in the vicinity of Hudson, Ohio.[2]

Walsh in 1869 states that several persons reported to him observations of its occurrence in injurious numbers in different parts of Missouri and southern Illinois. Riley makes the statement that in 1868 it was common in vineyards in Missouri along the Pacific & Iron Mountain Railroad, and that it was equally common around Alton, Ill. He was also informed that it had ruined 50 per cent of the grapes around Cleveland, Ohio, during the same season.

In 1870 Townend Glover reported it as occurring in large numbers on the fruit of grapevines in Maryland. In 1882 Saunders reported a serious outbreak of the pest in Canada, in vineyards in the vicinity of London, Ontario. In 1885 Dr. F. M. Goding reported it as being very injurious in vineyards near Ancona, Ill. Prof. F. M. Webster reported it as destroying 50 per cent of the grape crop in the vicinity of Cleveland, Ohio, in 1893. In this same year Prof. H. Osborn reported it as being injurious in vineyards near Des Moines, Iowa. In 1898 Prof. Webster again reported it as being very destructive in the vicinity of Cleveland and Gypsum, Ohio. In 1903 and again in 1905 Mr. A. F. Burgess found it very injurious in vineyards in the

[1] Bul. 223, Cornell Univ. Agr. Exp. Sta., pp. 57–59. [2] Riley, Missouri Report, 1869.

vicinity of Euclid, Ohio. He also reported it as being very injurious in vineyards on Kelleys Island, Ohio, in 1905. In 1906 it was reported by H. A. Gossard and J. S. Houser as again being very injurious in Ohio on Kelleys Island, South and Middle Bass Islands, and also in vineyards along Lake Erie east and west of Cleveland.

Prof. Slingerland (loc. cit.) reported that a correspondent informed him that the crop was entirely ruined by this insect in some vineyards at North East, Pa., in 1896. The same author makes the following statement in regard to serious infestations in the State of New York:

> There are doubtless more or less "wormy" grapes each year in practically every vineyard in New York State, so that the grape-berry moth is a constant menace. But it seems seldom to have been injurious since 1873, when it was first reported as increasing in numbers in the Hudson Valley. In 1898 it was a serious pest in the vineyard of a correspondent at Kendall, N. Y., and in 1902 reports reached us of its ravages all through the Chautauqua grapebelt. From portions of some vineyards near Brocton [N. Y.], a loss of from 25 to 50 per cent was reported, and in one case 90 per cent of the fruit was ruined.

During the investigations of grape insects at North East, Pa., by the Bureau of Entomology, the grape-berry moth was found to be very injurious over limited vineyard areas in this township in 1906, 1907, and 1908. In 1909 and 1910 the injury was not so great. In 1911, however, the infestation was noted to be quite heavy in two or three vineyards. Serious injury was also noted in vineyards in Ohio along the lake shore east and west of Cleveland, and also near Sandusky.

It is evident from these records that this is a serious enemy of the grape, of long standing and wide distribution throughout the vineyard areas of the eastern United States.

In the aggregate the crop loss due to its depredations must be very great, but owing to the irregularity with which the infestation occurs over vineyard areas it is exceedingly difficult to estimate the amount. For this reason the insect has not been subject to the persistent and painstaking efforts for its control on the part of the vineyardist that so destructive an insect pest seems to warrant.

HABITS OF THE ADULT OR MOTH.

The adult grape-berry moth is rarely seen in the vineyard, even in locations where it is quite abundant. It is a small slaty-brown moth with peculiar shaded brown markings on the forewings which render it quite inconspicuous upon the canes of the grapevine. When at rest with the wings folded it is about one-fourth of an inch long (see Pl. IV, fig. 2) and measures less than one-half inch across the outspread wings (see Pl. IV, fig. 1). In captivity in the rearing cages the moths were inactive during the day, remaining stationary upon the canes of the vine beneath the denser foliage or upon the woodwork of the

cage. Their position could be located only after an extended and careful search, so closely did their coloration harmonize with the background upon which they were at rest. Toward evening they became active, flying about the rearing cage and among the foliage of the vine, and at this time of day oviposition on the blossom clusters and berries doubtless occurs. At no time, however, were the females observed in the act of ovipositing. Practically all of the egg deposition on grape berries in the rearing cages occurred at night; hence there is no doubt that the moth is largely nocturnal in its activities. It has been observed quite frequently, however, that in the vineyards egg deposition is much heavier upon the grape clusters that are enveloped in dense foliage. This would indicate that conditions of subdued light are more favorable to oviposition than are exposed positions.

HABITS AND CHARACTER OF INJURY OF THE LARVA.

It is in the larval or caterpillar stage that this insect is injurious to the grape, and, as the popular name of the insect indicates, the berry or fruit is the part of the plant which it attacks. In 1868 Packard recorded the larva as feeding on the leaves, but the next year he corrected this error, and later observations by entomologists have failed to confirm this habit. The first larvæ to hatch are from eggs which are laid by the earliest emerging moths in spring and are doubtless deposited on the unexpanded blossom buds or on the stems of the blossom clusters. These larvæ attack the blossoms and the tiny berries. In the course of its movements, which must cover the entire blossom cluster, the larva spins a silken web. This web binds to each other and to the stem the dried corollas, stamens, and partly devoured berries, forming a conspicuous mass (see fig. 5). Usually, however, these webs formed during the blossoming period of the grape are not very numerous except in those portions of vineyards where the infestation is very heavy. In addition to attacking the blossoms and small berries of the young grape clusters the larva sometimes burrows into the stem, destroying a part of the cluster (see Pl. V, fig. 1). As the berries increase in size the small, scale-like, semitransparent eggs are readily found upon them. The portion of the berry at which the larva enters takes on a conspicuous purple color, and not infrequently the infested berries crack open as illustrated in Plate V, figure 2. In addition to destroying the berry first attacked, the larva connects it to an adjacent berry by silken strands, forming a tunnel between the partly injured berry and the sound one. This forms an avenue of escape for the larva when the berry first attacked is so badly injured that it breaks away from the stem (see Pl. V, fig. 2). When the larvæ of the first brood have

attained full growth they leave the web or the partly grown fruit and travel to the leaves, upon which they form pupal cases. The

FIG. 5.—Injury to grape cluster by larva of grape-berry moth during and just after the blooming period. (Original.)

larva makes the pupal case by cutting away a portion of the leaf and drawing the free edge down to the surface of the leaf with strands

FIG. 6.—Pupal cases made on grape leaf by full-grown larvæ of the first brood of the grape-berry moth. (Original.)

of silk (see fig. 6). The inside of the case is lined with the same silken material. In this case the larva transforms to the pupa (see

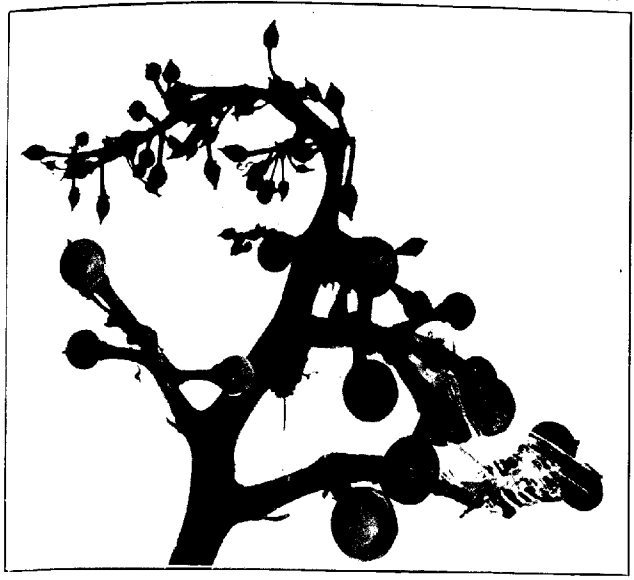


FIG. 1.—SHOWING DESTRUCTION OF PORTION OF GRAPE CLUSTER, AS A RESULT OF BORING OF LARVA INTO STEM; NOTE ALSO DRAWING TOGETHER OF BERRIES BY THE WEBB. (ORIGINAL.)

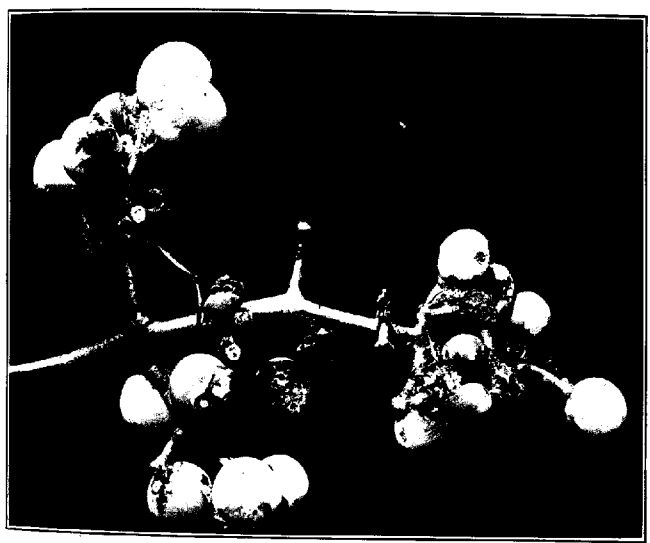


FIG. 2.—SHOWING CRACKING OF INFESTED BERRIES AND ALSO THE WAY IN WHICH BERRIES FIRST ATTACKED ARE SECURED BY WEB TO BERRIES WHICH ARE ATTACKED LATER IN THE DEVELOPMENT OF THE LARVA. (ORIGINAL.)

INJURY TO GRAPES BY LARVÆ OF FIRST BROOD OF GRAPE-BERRY MOTH.

FIG. 1.—SHOWING CLUSTERS OF CONCORD GRAPES FROM WHICH INFESTED BERRIES HAVE BEEN REMOVED. (ORIGINAL.)

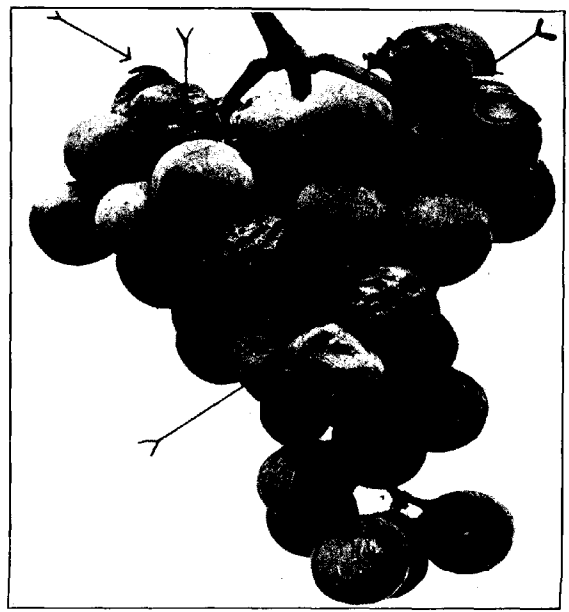


FIG. 2.—INJURY TO BERRIES BY LARVÆ JUST PREVIOUS TO HARVESTING OF FRUIT. (ORIGINAL.)

INJURY TO GRAPES BY LARVÆ OF SECOND BROOD OF GRAPE-BERRY MOTH.

Pl. IV, fig. 4), and the latter emerges as an adult moth (Pl. IV, fig. 1). These moths of the first brood deposit their eggs on the now nearly full-grown berries (see fig. 7). These second-brood eggs are usually more numerous than those of the first brood, if the infestation is at all serious. They are deposited upon the surface of the fruit and are quite conspicuous as white scale-like spots (see fig. 7). When the infestation is very heavy nearly all of the berries

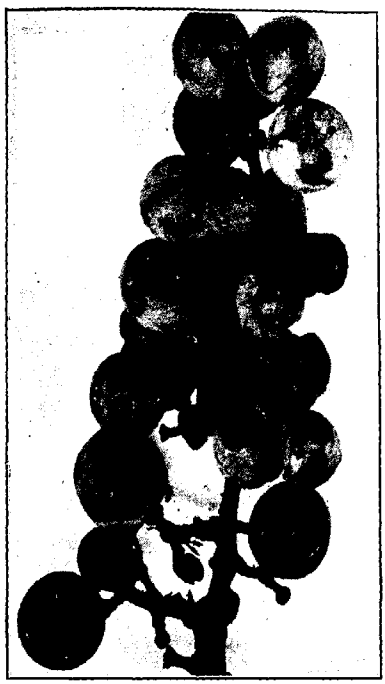


FIG. 7.—Cluster of Concord grapes on which many second-brood eggs of the grape-berry moth are present. The white spots indicate the appearance and position of the eggs. Eggs with black centers were parasitized. (Original.)

in the cluster may be attacked and the fruit rendered worthless. The larva feeds upon the pulp of the fruit and sometimes attacks the seeds before these commence to harden. By the time the grape crop is ready to harvest it is not unusual to find large numbers of clusters injured to the extent shown in Plate VI, figure 1. In Plate VI, figure 2, full-grown larvæ of the second brood are shown in the act of leaving the fruit for hibernation.

DESTRUCTIVENESS OF THE LARVA.

As indicated under the caption dealing with the character of injury, a single larva of the first brood may destroy almost an entire cluster about the time the grapes are in bloom (see fig. 5). For some time after blooming a larva is capable of destroying several berries or even a large portion of the cluster by attacking the stem. When berries are attacked after they have attained the size of a pea, however, rarely more than two or three are destroyed by a single larva. Yet this restriction in the number of berries injured by the individual larva is doubtless more than offset by the great increase in the number of larvæ of the second brood, which are not infrequently

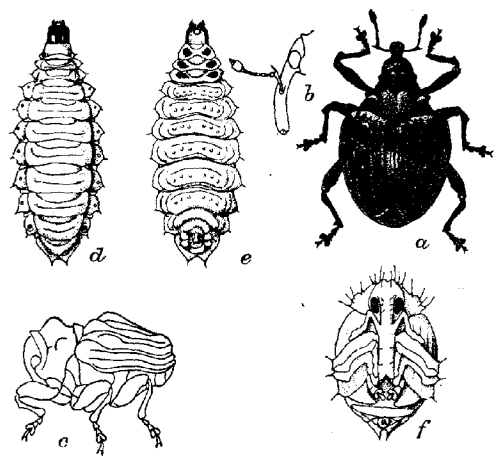


FIG. 8.—The grape curculio (*Craponius inæqualis*): *a*, Adult, or beetle, from above; *b*, head, antenna, and beak of same, from side; *c*, adult, from side; *d*, larva, from above; *e*, same, from below; *f*, pupa, from below. All much enlarged. (From Farmers' Bulletin 284.)

present in sufficient numbers to destroy nearly all of the berries in the cluster, as is shown in Plate VI, figure 1. From these clusters all the infested berries had been removed previous to taking the photograph.

OTHER INSECTS WHOSE INJURY TO GRAPE BERRIES RESEMBLES THAT CAUSED BY THE LARVA OF THE GRAPE-BERRY MOTH.

The only other insect attacking the berries of the grape whose injury to the fruit closely resembles that of the grape-berry moth is the grape curculio, *Craponius inæqualis* Say. This insect, however (see fig. 8, *a*), is one of the snout-beetles or curculios. Its injury to the grape berry is similar to that of the plum curculio upon the plum and other tree fruits. The grape curculio punctures the skin of the

green grape and eats out a small cavity beneath the skin in which to deposit its egg. This injury causes a purple spot on the surface of the berry similar to that which occurs at the point of entrance on the berry by the larva of the grape-berry moth. Where the two insects occur in the same vineyard their work is likely to be confused. The larva hatching from the egg of the grape curculio is a small, white, legless grub which tunnels to the center of the berry, feeds on the pulp, and frequently attacks the seed in much the same manner as does the larva of the grape-berry moth (see fig. 9, *d*). The larva of the grape-berry moth, however, is a caterpillar of a green or purplish color (see Pl. IV, fig. 3), having six well-developed legs and a longer and more slender body, is very active in its movements, and when disturbed by cutting open the berry which it infests is likely to wriggle from its tunnel and drop to the ground.

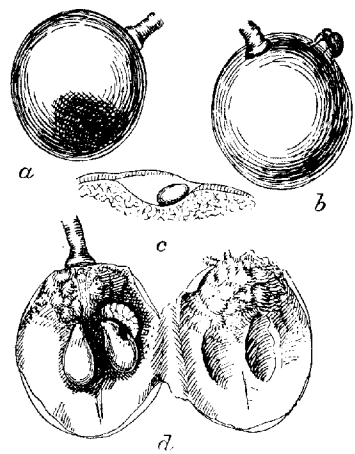


FIG. 9.—Work of the grape curculio in berry of grape: *a*, Berry from which grub or larva has emerged; *b*, adult or weevil ovipositing on berry; *c*, enlarged section of portion of berry, showing egg cavity and egg; *d*, injured berry cut open, showing larva at work. *a*, *b*, *d*, Enlarged; *c*, highly magnified. (From Farmers' Bulletin 284.)

The grape curculio is not a common pest in the vineyards of New York State and in the vicinity of the Great Lakes.

During the investigation of grape insects covering the past five years only two light infestations of this insect have been observed in the vineyards of the Lake Erie Valley. It is, however, a common vineyard pest in West Virginia and in many of the States of the Mississippi Valley and the Middle West. Since the beetles feed on the foliage of the grapevine it is readily controlled by spraying with arsenate of lead, the applications being made at the same date as recommended against the larvæ of the grape-berry moth and the grape rootworm.

An account of the life history and habits of the grape curculio, including methods for its control, are given in Farmers' Bulletin 284 on "Insect and Fungous Enemies of the Grape East of the Rocky Mountains," by Messrs. A. L. Quaintance and C. L. Shear.

There is also a minute chalcis fly,[1] *Eroxysoma vitis* Saunders, which caused some alarm among vineyardists in Canada when it was discovered in the vicinity of London, Ontario, by Saunders in

[1] Can. Farmer, October 15, 1868, p. 316.

1868, infesting seeds of several varieties of cultivated grapes, namely, Clinton, Delaware, Rogers No. 4, and an unnamed seedling variety. Since that time, however, this insect has failed to materialize as a serious enemy to cultivated varieties of grapes. The adult is a minute hymenopterous fly. The female insect deposits its eggs by means of its long ovipositor through the pulp of the grape berry into the seed. The larva hatching from this egg is a minute grub, which feeds upon the pulp within the seed, in which it reaches full development. Grape berries infested by this pest shrivel and drop before the ripening period. This shriveled condition of the berries infested by this grape-seed chalcis is the only evidence of its injury that is likely to be confused with that of the larva of the grape-berry moth.

DESCRIPTION.

THE EGG.

The eggs of the grape-berry moth are oval, scale-like, semitransparent bodies about 1.75 mm. by 1.25 mm. in diameter. They are solidly glued to the surface of the berry and although quite flat they are somewhat more rounded and smaller than those of the codling moth, which they greatly resemble. Before the larvæ hatch from them the eggs are not very conspicuous, especially upon the green berries, since on account of their transparency they become lost in the ground color of the berry. The eggshell is finely reticulate. The development of the larva can be readily observed through the transparent shell. After the larva hatches the eggshell remains upon the surface of the berry and can be more readily seen than the egg itself and appears as a whitish spot possessing a pearly iridescence. Upon the purple background of the ripening fruit the eggs are much more conspicuous than upon the green berries, as shown in figure 7. The eggs with dark centers have been parasitized by the egg parasite *Trichogramma pretiosa* Riley.

THE LARVA.[1]

Larva:—9 to 10 mm. Cylindrical, rather robust, tapering from [segment] 4 to head and [segment] 8 to anal segment. Pale olivaceous-green, with a reddish or purplish tinge from food. Head flattened, slightly bilobed, luteous green on upper parts of lobes, discolored by brown in front; mouth parts and a horizontal dash on side of each lobe below middle black. Pro-thoracic shield large but narrow, luteous brown, bisected by pale green dorsal line. Thoracic feet black, green between joints. Tubercles plates moderate, a slight shade darker than skin, shining. Anal plate not chitinous.

[1] Description by W. D. Kearfott, Trans. Amer. Ent. Soc., vol. 30, p. 293, 1904.

THE PUPA.

The pupæ are 5 mm. (three-sixteenths inch) in length, light greenish brown, with eyes and caudal border of abdominal segments and last two or three segments darker brown. There is a row of coarse short spines near the cephalic border, a row of finer ones along the caudal border of the dorsum of each abdominal segment, and eight bristles, with recurved tips for hooking into the silken cocoon, occur around the tip of the abdomen. On emergence of the adult from the cocoon the exuviæ are drawn about halfway out of the cocoon.

THE ADULT.[1]

Eudopiza viteana Clem., Proc. Acad. Nat. Sci. Phila. 359, 1860.
Carpocapsa vitisella, Rathvon, Prac. Farmer, p. 170, 1868.
Penthina vitivorana Pack., Guide Study Ins., 336, 1869.

Head, thorax, palpi light brown, specked with darker brown, lower and outer sides and tips of palpi and posterior thoracic tuft dark brown.

Forewing:—Ground color, lilaceous-blue, middle fascia and large spots brown, overlaid with much black. Costal spots lighter brown. A dash of white about middle of outer third.

Base to middle fascia lilaceous-blue, inner fascia almost obsolete, represented by a narrow band of black scales, each fringed with light brown, from dorsum but not reaching costa by a quarter, three small spots and two small ones between them of brown-black scales on costa before middle fascia. And in the same space on dorsum four black dots, the dorsal margin narrowly overlaid with light fuscous, brown and black scales, causing a mottled appearance.

The middle fascia is evenly convex on its inner edge, and is of almost even width throughout, except at about middle of wing, the outer edge curves downward and outward at right angles to the band, and then turns abruptly upward to costa (in the curve thus formed rests the white oblique patch) from outer end of this branch the outer line of fascia continues inwardly oblique to costa, slightly indented, the lower half of fascia triangular. Color smoky-black on upper half, a small patch of same at one-third above dorsum, otherwise smoky brown, lightest at dorsum. Before anal angle is a triangular brown spot. Above the angle an irregular rounded blotch of brown and black, indented at its lower outward corner by a spur of the ground color, its outline also broken by a spur of ground color on its outer upper edge. Apical spot flatly triangular. Ground color of costal margin between fascia and apex, whitish blue, four brown costal spots in this space, the inner a mere outwardly oblique line curving into outer lower end of second spot, latter and fourth are triangular-oblique, third spot rectangular. Below these spots and above the white patch are scattered a few brown scales. Cilia bluish grey, darker at apex and light fuscous at anal angle. Underside dark fuscous, whitish below fold, three geminated whitish spots on costa before apex, and a number of others on extreme edge of costa only, between these and base, cilia darker with narrow light subciliate line.

Abdomen smoky black, with metallic reflection, anal tuft silvery-white above, yellowish beneath, tipped with dark fuscous; underside abdomen whitish; legs same inwardly and between joints, outwardly smoky-black.

Hind wing:—Smoky fuscous, lighter towards base, darkest at apex, cilia paler; underside fuscous.

[1] Description by W. D. Kearfott, Trans. Amer. Ent. Soc., vol. 30, pp. 292-293, 1904.

SEASONAL HISTORY.

Observations on the life history of the grape-berry moth extend over the seasons of 1907, 1908, and 1909. During the latter year special efforts were made to obtain complete records on the development of the insect in its various stages. In many respects the seasonal conditions during 1907 and 1908 were unusual, the spring of 1907 being late and the entire season of 1908 unusually early. The season of 1909 was in most respects normal.

LIFE-HISTORY STUDIES IN 1909.

The emergence record of the spring brood of the grape-berry moth was secured from leaves upon which larvæ had made cocoons during the fall of 1908. These leaves were left out of doors in a cage all

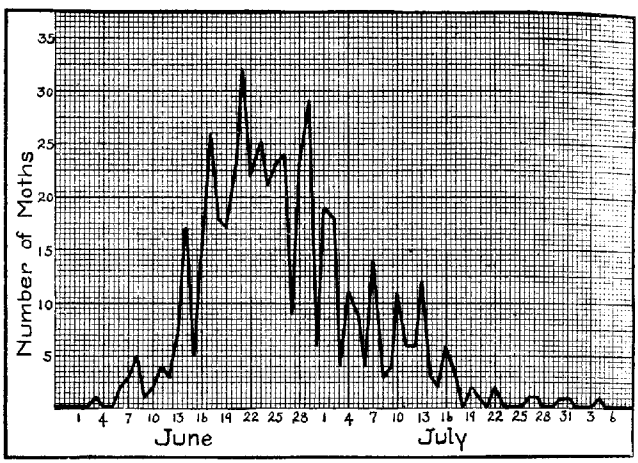


FIG. 10.—Diagram showing time of emergence of spring-brood moths of the grape-berry moth in 1909, at North East, Pa. (Original.)

winter so as to be subject, as nearly as possible, to natural conditions. On May 17, 1909, 1,000 of these cocoons were separated from this mass of leaves and placed in jars in an outdoor rearing shelter (see Pl. VII, fig. 1) and the following emergence record was secured by a daily examination of the jars and the removal of all moths.

SPRING BROOD OF MOTHS.

Time of emergence of spring brood of moths.—Table I gives the emergence of all the moths from these jars. The total number of moths to emerge was 507. The number of moths that emerged from June 3 to June 14 was 28, or 5.5 per cent; from June 14 to July 14, 455, or 89.8 per cent; from July 14 to August 5, 24, or 4.7 per cent. The maximum emergence occurred June 21. (See fig. 10, showing time of emergence of the spring-brood moths.)

TABLE I.—*Time of emergence of moths of the grape-berry moth in the spring of 1909 at North East, Pa.*

Date of emergence.	Number of moths.	Date of emergence.	Number of moths.	Date of emergence.	Number of moths.	Date of emergence.	Number of moths.	Date of emergence.	Number of moths.
June 3	1	June 18	18	July 1	19	July 14	3	July 30	1
6	2	19	17	2	18	15	2	31	1
7	3	20	23	3	4	16	6	Aug. 1	0
8	5	21	32	4	11	17	3	2	0
9	1	22	22	5	9	19	2	3	0
10	2	23	25	6	4	20	1	4	1
11	4	24	21	7	14	22	2	5	0
12	3	25	23	8	3	23	0		
15	7	26	24	9	4	24	0	Total.	507
14	17	27	9	10	11	25	0		
15	5	28	23	11	6	26	1		
16	14	29	29	12	6	27	1		
17	26	30	6	13	12	28	0		

Since the blossoming period of the grape in the Lake Erie Valley occurs usually from June 13 to June 20, this emergence record of the spring moths indicates that the maximum emergence takes place during and after the blossoming period. This record also indicates that the small percentage of webs containing larvæ found in the blossom clusters does not represent the full spring brood from spring-emerging moths, as has been supposed by some investigators, but merely represents the offspring of a very small percentage of the earliest appearing moths.

Oviposition of spring-emerging moths in confinement.—The female grape-berry moth does not oviposit readily in confinement, which accounts for the somewhat meager oviposition records obtained. No eggs were observed in our rearing cages until the berries of the grape were formed and those found were always deposited upon the berries.

TABLE II. *Oviposition of spring moths of the grape-berry moth in stock jars at North, East, Pa., 1909.*

No. of stock jar.	Number of moths.	Date of—			Days—		
		Emergence of moths.	First oviposition.	Last oviposition.	Before oviposition.	Of oviposition.	From emergence to last oviposition.
1	10	June 17	July 1	July 5	14	5	18
2	30	June 18	June 24	July 2	6	9	14
3	15	June 19	...do....	June 30	5	7	11
4	20	June 20	June 30	...do....	10	1	10
5	46	June 21 to June 22	June 25	July 5	4	11	14
6	12	June 23	June 27	July 7	4	11	14
7	16	June 24	July 1	July 1	7	1	7
8	20	June 25	June 29	July 8	4	10	13
9	23	June 26	June 30	July 12	4	13	16
10	29	June 29	July 7	July 9	8	3	10
Average					6.6	7.1	12.7
Maximum					14	13	18
Minimum					4	1	7

Table II gives a record of oviposition by spring-emerging moths secured during the season of 1909. This table gives the number of days between emergence of the moth and the first oviposition and also the number of days between emergence and the last oviposition. The minimum period before first oviposition was 4 days; the average 6.6 days; the maximum 13 days. The average period between the first and last ovipositions was 7.1 days. The longest period between emergence and the last oviposition was 18 days.

Length of life of spring brood of moths.—Records from our rearing cages show that many of the moths will live in confinement for a number of days, especially when food in the form of honey or sweetened water is supplied. Table III gives the length of life of 76 moths, showing that the minimum life period was 4 days, the average 12.9 days, and the maximum 23 days. The average length of life of the moths recorded in this experiment very closely approximates that of the moths recorded in Table II, which was 12.7 days.

TABLE III.—*Length of life of moths of the spring brood of the grape-berry moth in confinement, with food, at North East, Pa., in 1909.*

Number of moths.	Date—		Length of life.	Number of moths.	Date—		Length of life.
	Emerged.	Dead.			Emerged.	Dead.	
			Days.				*Days.*
4	June 19	July 3	14	3	June 23	July 16	23
4	...do....	July 6	17	10	June 24	July 2	8
4	...do....	July 7	18	1	...do....	July 7	13
2	...do....	July 8	19	1	...do....	July 9	15
1	...do....	July 9	20	1	...do....	July 11	17
6	June 20	June 29	9	4	July 4	July 12	8
5	...do....	July 1	11	2	...do....	July 14	10
8	...do....	July 3	13	1	...do....	July 15	11
2	...do....	July 9	19	1	...do....	July 16	12
6	June 23	July 8	15	3	July 13	July 17	4
1	...do....	July 10	17	2	...do....	July 24	11
2	...do....	July 12	19	2	...do....	July 26	13

Total number of moths		76
Length of life:		
Average	days..	12.9
Maximum	do....	23
Minimum	do....	4

FIRST GENERATION.

Incubation period of first-brood eggs.—Table IV gives a record of the length of the egg stage for 21 eggs of the first brood deposited on grape berries in the field rearing cage. The minimum length of the egg stage for this number of eggs was 4 days, the average 6 days, and the maximum 8 days.

FIG. 1.—PORTION OF OUTDOOR SHELTER USED IN THE REARING OF INSECTS DURING 1909. (ORIGINAL.)

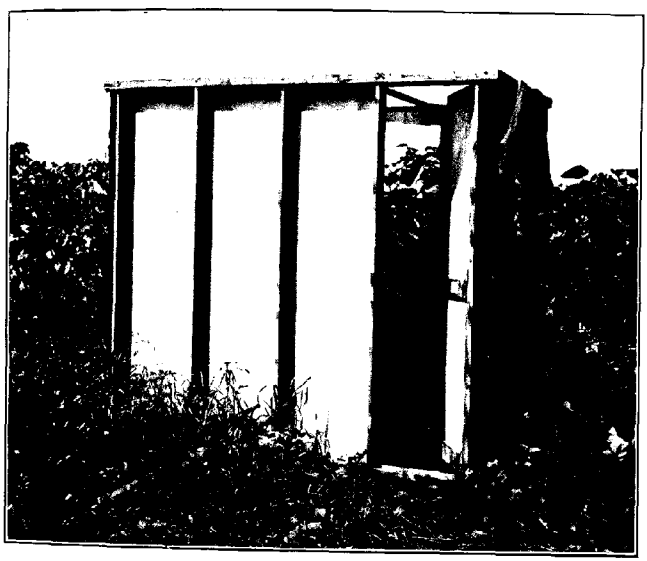


FIG. 2.—CAGE BUILT OVER GRAPEVINE IN WHICH THE GENERATIONS OF THE GRAPE-BERRY MOTH WERE REARED DURING 1909. (ORIGINAL.)

OUTDOOR REARING SHELTER AND CAGE USED IN LIFE-HISTORY STUDIES AT NORTH EAST, PA.

TABLE IV.—*Length of incubation of first brood of eggs of the grape-berry moth at North East, Pa., in 1909.*

No. of observation.	Date—		Days of incubation.	No. of observation.	Date—		Days of incubation.
	Laid.	Hatched.			Laid.	Hatched.	
1	June 25	June 29	4	12	July 3	July 10	7
2	June 26	July 1	5	13	...do...	July 11	8
3	June 27	July 2	5	14	July 5	...do...	6
4	June 28	July 4	6	15	July 6	July 12	6
5	...do...	July 5	7	16	July 7	...do...	5
6	June 29	...do...	6	17	July 8	July 13	5
7	...do...	July 6	7	18	July 9	...do...	4
8	June 30	July 7	7	19	July 10	July 16	6
9	July 1	July 8	7	20	July 12	July 17	5
10	July 2	July 9	7	21	...do...	July 18	6
11	...do...	July 10	8				

Days of incubation:

Average	6
Maximum	8
Minimum	4

Length of feeding period of first-brood larvæ.—The records for the length of the feeding period of the first-brood larvæ are given in Table XI (p. 37), which shows a range from 19 to 33 days and an average of 23.2 days. The small number of observations made was due to the difficulty of securing the deposition of a larger number of eggs from the moths in captivity.

Length of pupal stage of first brood.—Table V gives the time of leaving the fruit of 285 first-brood larvæ and the date of emergence of the moths. The average time for making the cocoon was approximately 2 days. The minimum time covered from leaving of fruit to emergence of moths was 10 days, the average 15.2 days, and the maximum 25 days. Therefore, deducting 2 days spent by the larva in making the cocoon the minimum pupal period was 8 days, the average 13.2 days, and the maximum 23 days.

TABLE V.—*Time of cocooning and the length of the pupal stage of the first brood of the grape-berry moth at North East Pa., in 1909.*

Number of larvæ.	Larvæ left fruit.	Moths emerged.	Days—		Number of larvæ.	Larvæ left fruit.	Moths emerged.	Days—	
			In cocoon.	Total.				In cocoon.	Total.
3	July 29	Aug. 10	12	36	3	Aug. 6	Aug. 24	18	54
7	do	Aug. 14	16	112	2	Aug. 7	Aug. 20	13	26
2	do	Aug. 13	15	30	1	do	Aug. 21	14	14
1	do	Aug. 23	25	25	7	do	Aug. 22	15	105
1	July 30	Aug. 9	10	10	1	do	Aug. 23	16	16
2	do	Aug. 10	11	22	6	do	Aug. 24	17	102
1	do	Aug. 12	13	13	1	do	Aug. 27	20	20
4	do	Aug. 13	14	56	1	Aug. 8	Aug. 23	15	15
9	do	Aug. 14	15	135	6	do	Aug. 24	16	96
2	do	Aug. 15	16	32	17	do	Aug. 25	17	289
1	do	Aug. 16	17	17	2	do	Aug. 26	18	36
8	July 31	Aug. 14	14	112	1	do	Aug. 27	19	19
4	do	Aug. 15	15	60	1	Aug. 9	Aug. 22	13	13
1	do	Aug. 16	16	16	5	do	Aug. 25	16	80
14	Aug. 1	Aug. 15	14	196	12	do	Aug. 26	17	204
9	do	Aug. 16	15	135	2	do	Aug. 27	18	36
3	Aug. 2	Aug. 15	13	39	1	Aug. 10	Aug. 22	12	12
8	do	Aug. 16	14	112	10	do	Aug. 26	16	160
2	do	Aug. 17	15	30	9	do	Aug. 27	17	153
1	Aug. 3	Aug. 13	10	10	8	do	Aug. 28	18	144
2	do	Aug. 16	13	26	1	do	Aug. 29	19	19
13	do	Aug. 17	14	182	1	Aug. 11	Aug. 22	11	11
5	do	Aug. 18	15	75	1	do	Aug. 25	14	14
3	do	Aug. 19	16	48	2	do	Aug. 26	15	30
2	Aug. 4	Aug. 17	13	26	4	do	Aug. 27	16	64
3	do	Aug. 18	14	42	1	do	Aug. 28	17	17
2	do	Aug. 19	15	30	1	do	Aug. 29	18	18
2	do	Aug. 20	16	32	2	Aug. 12	Aug. 27	15	30
4	Aug. 5	Aug. 19	14	56	3	do	Aug. 28	16	48
5	do	Aug. 20	15	75	3	do	Aug. 29	17	51
3	do	Aug. 22	17	51	1	do	Sept. 1	20	20
19	Aug. 6	Aug. 19	13	247					
19	do	Aug. 20	14	266	285				4,334
4	do	Aug. 22	16	64					

	Days.
Average	15.2
Maximum	25
Minimum	10

Time of emergence of first-brood moths.—The material for securing this emergence record of the first-brood moths was taken in part from the large rearing cage in which the eggs had been deposited by earliest emerging moths in the spring. Infested grape berries were removed from the vine in this cage a short time before the larvæ had reached their full growth. The rest of the material was collected from the open vineyard on August 2, 9, and 10. Since larvæ were found in webbed clusters in the open vineyard several days before any larvæ were found in the rearing cage it is probable that a few of the earliest full-grown larvæ of the first brood had escaped from the fruit before it was collected to secure this record, thus making the date of the first-emerging moth in this record a few days later than actually occurred under field conditions. Since the date of the last moth of the spring brood to emerge in our rearing jars was August 4, and the date of the first moth to appear from the first-brood rearing material was July 31, there is evidently an overlapping in the emergence of

moths of the two broods in the field. Table VI contains a record of the emergence of 403 moths, and a glance at the table will show that the maximum number of these first-brood moths emerged from August 14 to August 29. The rate of emergence is graphically shown by the curve in figure 11.

TABLE VI.—*Time of emergence of moths of the first brood (summer moths) of the grape-berry moth at North East, Pa., in 1909.*

Date of emergence.	Number of moths.	Date of emergence.	Number of moths.	Date of emergence.	Number of moths.	Date of emergence.	Number of moths.
July 31	1	Aug. 19	34	Aug. 30	5	Sept. 10	1
Aug. 9	1	20	32	31	13	11	0
10	5	21	1	Sept. 1	4	12	1
11	0	22	17	2	9	13	3
12	9	23	7	3	7	14	0
13	7	24	19	4	4	15	0
14	18	25	23	5	0		
15	28	26	27	6	4	Total..	403
16	24	27	23	7	2		
17	18	28	27	8	1		
18	10	29	18	9	1		

Oviposition of first-brood moths.—The oviposition records of only a few moths of the first brood were secured and are not numerous enough to give an adequate idea of the length of this period. The

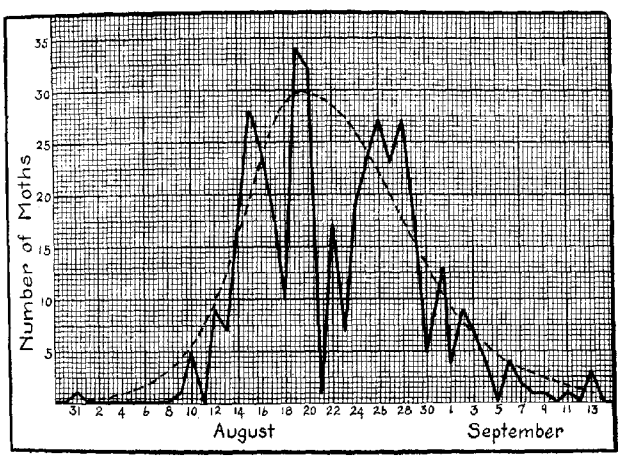


FIG. 11.—Diagram showing time of emergence of the first-brood moths of the grape-berry moth in 1909, at North East, Pa. (Original.)

same difficulty in getting the moths to oviposit freely in confinement was encountered as with the spring-emerging moths. Table VII gives the oviposition of a few individuals of the first brood.

TABLE VII.—*Oviposition of first-brood moths of the grape-berry moth in stock jars at North East, Pa., in 1909.*

No. of stock jar.	Number of moths.	Date of—			Days—		
		Emergence of moths.	First oviposition.	Last oviposition.	Before oviposition.	Of oviposition.	From emergence to last oviposition.
1.....	10	Aug. 18	Aug. 27	Aug. 27	9	1	9
2.....	21	Aug. 19	...do....	Sept. 8	8	13	20
3.....	21	Aug. 20	...do....	Aug. 27	7	1	7
4.....	4	Aug. 27	Sept. 5	Sept. 5	9	1	1
Average.....					8.2	4	9.2
Maximum.....					9	13	20
Minimum.....					7	1	1

Hibernation of first-brood pupæ.—Toward the end of July before the eggs of the second brood had been deposited a large number of infested grape berries were collected in order to determine if all of the first brood completed the cycle and emerged as adults, or if some of them passed the winter as pupæ.

Tables VIII and IX give the record for 374 larvæ. Deducting the dead and parasitized individuals from this number, a complete record of 321 specimens was secured. Two hundred and ninety-two adults emerged from July 29 to August 15. After the latter date no adults emerged. Twenty-nine live pupæ failed to transform and hibernated.

TABLE VIII.—*The relative number of transforming and wintering individuals of the first brood of the grape-berry moth, North East, Pa., 1909.*

Number of larvæ.	Date larvæ left berry.	Number of—			
		Moths emerged.	Larvæ hibernating.	Larvæ parasitized.	Dead.
19	July 29	13	0	0	6
20	July 30	20	0	0	0
13	July 31	12	0	0	1
21	Aug. 1	21	0	0	0
16	Aug. 2	14	0	0	2
32	Aug. 3	30	0	1	1
13	Aug. 4	10	0	2	1
18	Aug. 5	12	0	2	4
50	Aug. 6	45	0	1	4
23	Aug. 7	19	0	1	3
36	Aug. 8	30	2	0	4
25	Aug. 9	20	0	1	4
32	Aug. 10	24	1	1	6
15	Aug. 11	10	3	1	1
13	Aug. 12	11	1	1	0
1	Aug. 15	1	0	0	0
10	Aug. 26	0	9	0	1
7	Sept. 11	0	7	0	0
5	Sept. 13	0	4	0	1
3	Sept. 12	0	1	0	2
2	Sept. 18	0	1	0	1

TABLE IX.—*Summary of Table VIII showing number and percentage of first-brood larvæ of the grape-berry moth that transform.*

Observations on—	Number.	Per cent.
Number of larvæ	374	100.0
Number of moths emerged	292	78.1
Number of hibernating pupæ	29	7.8
Number of parasitized larvæ	11	2.9
Number of dead individuals	42	11.2

Length of life cycle of first generation.—The results of the preceding observations on the separate stages of the grape-berry moth have been summarized in Table X, which shows an average period of 44.2 days for the life cycle of the first generation.

TABLE X.—*Life cycle of the first generation of the grape-berry moth as determined from observations on the separate stages; summaries from the previous tables.*

Stages of development.	Average.	Maximum.	Minimum.
	Days.	*Days.*	*Days.*
Egg stage	6.0	8	4
Length of feeding	23.0	33	19
Making of cocoon	15.2	25	10
Pupal stage			
Days duration of life cycle	44.2	66	33

TABLE XI.—*Life cycle of the first generation of the grape-berry moth, as observed by rearing in 1909 at North East, Pa.*

No.	Dates of—					Days duration—				
	Egg deposition.	Hatching.	Leaving fruit.	Pupation.	Emergence of moths.	Incubation of eggs.	Feeding period of larvæ.	Larvæ making cocoon.	Pupal stage	Life cycle.
1	July 2	July 10	Aug. 5	Aug. 9	.....	8	26	4	.....	.....
2	July 3	July 11	July 31	.....	Aug. 14	8	20	.....	.....	42
3	July 5	...do.....	...do.....	.....	Aug. 18	6	20	.....	.....	44
4	July 7	July 12	...do.....	.....	Aug. 16	5	19	.....	.....	40
5	...do.....	...do.....	Aug. 6	Aug. 7	.....	5	25	1	.....	.....
6	July 8	July 13	Aug. 4	Aug. 6	.....	5	22	2	.....	.....
7	...do.....	...do.....	Aug. 5	...do.....	Aug. 19	5	23	1	13	42
8	...do.....	...do.....	.....	.....	...do.....	5	.....	.....	.....	42
9	July 9	...do.....	Aug. 5	Aug. 6	.....	4	23	1	.....	.....
10	...do.....	...do.....	Aug. 6	Aug. 7	.....	4	24	1	.....	.....
11	...do.....	...do.....	Aug. 15	Aug. 17	Aug. 31	4	33	2	14	53
12	July 10	July 16	Aug. 5	Aug. 8	.....	6	20	3	.....	.....
Average						5.4	23.2	1.9	13.5	43.8
Maximum						8	33	3	14	53
Minimum						4	19	1	13	40

The average figures in Table X agree closely with the results obtained from the rearings of life-cycle series (Table XI). It will be noted under the life-cycle column that six individuals completed their life cycle the same season, while six pupæ wintered. The shortest

life-cycle period was 40 days, the average length 43.8 days and the longest 53 days. There is a difference of less than half a day in the averages for the two separate rearings.

SECOND GENERATION.

Incubation period of second-brood eggs.—For reasons previously assigned the record of egg laying by the moths in confinement is very scanty. Table XII gives the length of this stage for nine eggs of known origin. The incubation period of these eggs is longer than in the record secured for eggs deposited by the spring-emerging moths. The number of eggs recorded, however, is far too small to admit of generalization on this topic.

TABLE XII.—*Length of incubation of second-brood eggs of the grape-berry moth. North East, Pa., 1909.*

No. of observation.	Date—		Days of incubation.	No. of observation.	Date—		Days of incubation.
	Laid.	Hatched.			Laid.	Hatched.	
1	Aug. 27	Sept. 7	11	6	Sept. 2	Sept. 12	10
2	Aug. 30	Sept. 9	10	7	Sept. 4	Sept. 13	9
3	...do.....	Sept. 10	11	8	...do.....	Sept. 14	10
4	Aug. 31	Sept. 11	11	9	Sept. 5	...do.....	9
5	Sept. 1	...do.....	10				

Days of incubation:

Average	10.1
Maximum	11
Minimum	9

Length of feeding period of second-brood larvæ.—Tables XIII-XIV give the feeding period of second-brood larvæ under two entirely different conditions, namely, larvæ reared on green fruit in stock jars under a rearing shelter (Table XIII) and larvæ feeding on fruit growing on a vine (Table XIV) in a large outdoor rearing cage (see Pl. VII, fig. 2).

TABLE XIII.—*Length of the feeding period of the second-brood larvæ of the grape-berry moth under confinement in jars, North East, Pa., 1909.*

No. of observation.	Larvæ hatched.	Larvæ left fruit.	Number of days.	No. of observation.	Larvæ hatched.	Larvæ left fruit.	Number of days.
1	Aug. 27	Oct. 6	40	12	Aug. 30	Oct. 26	57
2	...do.....	Oct. 9	43	13	...do.....	Nov. 1	63
3	Aug. 29	Oct. 17	49	14	...do.....	...do.....	63
4	...do.....	...do.....	49	15	Sept. 11	Nov. 3	53
5	...do.....	Oct. 20	52	16	...do.....	Oct. 25	44
6	...do.....	Oct. 21	53	17	...do.....	Nov. 3	53
7	...do.....	...do.....	53	18	...do.....	...do.....	53
8	Aug. 30	Oct. 22	53	19	...do.....	...do.....	53
9	...do.....	Oct. 25	56	Average			52.6
10	...do.....	...do.....	56	Maximum			63
11	...do.....	...do.....	56	Minimum			40

TABLE XIV.—*Length of the feeding period of second-brood larvæ of the grape-berry moth in fruit on the vines under large outdoor rearing cages, North East, Pa., 1909.*

Number of larvæ.	Larvæ hatched.	Larvæ left fruit.	Number of days.	Number of larvæ.	Larvæ hatched.	Larvæ left fruit.	Number of days.
6	Aug. 25	Sept. 25	31	9	Aug. 25	Oct. 7	43
1	...do.....	Sept. 26	32	1	...do.....	Oct. 8	44
3	...do.....	Sept. 27	33	6	...do.....	Oct. 9	45
9	...do.....	Sept. 28	34	7	...do.....	Oct. 10	46
1	...do.....	Sept. 29	35	7	...do.....	Oct. 11	47
8	...do.....	Oct. 2	38	1	...do.....	Oct. 17	53
7	...do.....	Oct. 3	39	Average.....			40.3
7	...do.....	Oct. 4	40	Maximum.....			53
10	...do.....	Oct. 5	41	Minimum.....			31
8	...do.....	Oct. 6	42				

The infested grape clusters were removed from the cage just before the larvæ were ready to leave the berries. These larvæ hatched from eggs deposited between August 20 and 25. It was impossible to determine the exact date of hatching of all of the eggs, but only a very small number hatched previous to August 25 and this may account in a measure for the shorter average period of feeding than is recorded for the larvæ from the stock jars. In addition to this all but one of these larvæ had left the fruit previous to the occurrence of a decided drop in temperature between October 12 and 20, whereas only two of the larvæ had emerged from the fruit in the stock jars. Hence, since insect activities were slight during this cold wave the period spent in the fruit by those larvæ which had not escaped previous to its occurrence was abnormally prolonged.

The minimum period spent in fruit by larvæ in the rearing cage was 31 days as against 40 days by those in stock jars; the average 40.3 days as against 52.6 days, and the maximum 53 days as against 63 days.

Date second-brood larvæ leave fruit.—A record was made of the period during which the larvæ leave the berries, with a view to ascertaining whether many of them are likely to be removed from the vineyard when the ripe grapes are being marketed. A large number of larvæ which infested grape clusters were collected from vineyards August 20-24. At this date few if any of the larvæ of the second brood had fully matured. Since the emergence of the two broods of moths overlap it is quite likely that some of the larvæ in this record belong to the first brood. Daily examinations of the collected material were made and the record of the larvæ leaving the fruit is given in Table XV.

TABLE XV.—*Time of second-brood larvæ of the grape-berry moth leaving berries in 1909, from fruit collected in the field, North East, Pa.*

Date of leaving the fruit.	Number of larvæ.	Date of leaving the fruit.	Number of larvæ.	Date of leaving the fruit.	Number of larvæ.	Date of leaving the fruit.	Number of larvæ.
Sept. 22	11	Oct. 6	53	Oct. 20	2	Nov. 3	6
23	21	7	50	21	9	4	0
24	15	8	40	22	5	5	1
25	19	9	38	23	5	6	0
26	8	10	50	24	0	7	1
27	11	11	24	25	7	8	7
28	16	12	14	26	13	9	3
29	21	13	5	27	1	10	0
30	12	14	0	28	0	11	2
Oct. 1	12	15	2	29	4	12	4
2	73	16	1	30	1	13	1
3	39	17	2	31	4	14	2
4	38	18	4	Nov. 1	24		
5	45	19	0	2	19	Total.	745

In all, 745 larvæ emerged. The table shows that 569, or four-fifths of the larvæ, left the fruit in 20 days, from September 22 to October 11, and that the remaining 149, or one-fifth, left the fruit between October 12 and November 14, a period of 34 days, making a total period of 45 days during which second-brood larvæ were leaving the fruit. Since the heavy shipment of Concord grapes does not

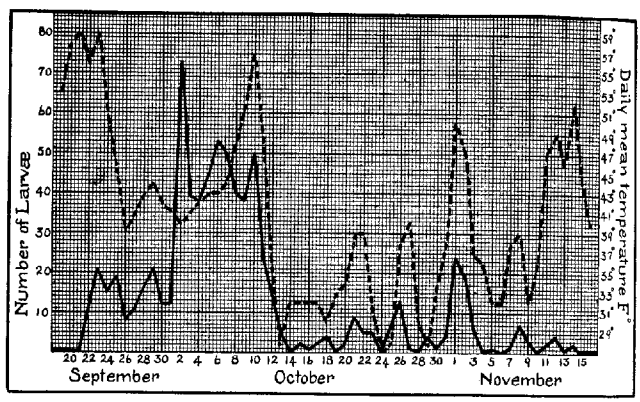


FIG. 12.—Diagram showing time of leaving the grape berries by second-brood larvæ of the grape-berry moth, from fruit collected in the field, North East, Pa., 1909. Daily mean temperature Fahrenheit. (Original.)

occur until October 1, fruit in infested vineyard areas would have to be removed during the first week of the picking season in order to remove many of the larvæ from the vineyard with the crop.

Figure 12 shows the correlation between the fluctuations of temperature and the activity of the mature larvæ of the second brood in leaving the grape berries in the fall of 1909. The dotted line represents the daily mean temperature, and the solid line the rate of emergence of the larvæ from the berries. It will be observed that

there was a period of very low temperature from October 14 to 18, and that this is correlated with an almost complete cessation of emergence of the larvæ. There is no doubt that the abnormally low temperature for this date prolonged the emergence period of the larvæ for the season of 1909.

MISCELLANEOUS REARING RECORDS FOR THE SEASONS OF 1907 AND 1908.

The rearing records for the seasons of 1907 and 1908 are less extensive and not so complete as those made a year later, but they agree in general with the more complete records of 1909. Table XVI gives the emergence record of 24 moths of the spring brood for the season of 1907.

TABLE XVI.—*Time of emergence of moths of the grape-berry moth in the spring of 1907.*

Date of emergence.	Number of moths.	Date of emergence.	Number of moths.	Date of emergence.	Number of moths.	Date of emergence.	Number of moths.
June 21	1	June 25	4	June 30	1	July 6	1
22	1	26	3	July 2	1	7	1
23	1	28	3	3	1	10	1
24	3	29	1	4	1		

No record of egg deposition by the spring brood of moths was secured for the season of 1907, nor was a record made of the length of the larval stage for the first brood.

The complete record of two pupæ of the first brood was secured during 1907 which covered a period of 13 days for this stage, and a record of one pupa in 1908 which covered a period of 12 days. These records are shorter than the average length of this stage for a large number of specimens observed in 1909 (see Table V, which shows a period of 15.2 days).

An emergence record of 695 moths of the first brood was secured during the season of 1907. (See Table XVII.) Unfortunately some of the earliest maturing larvæ had escaped from the infested fruit before it was collected. Hence some of the earliest emerging moths are not shown, since the first emergence in this record is dated August 17.

TABLE XVII.—*Time of emergence of first-brood moths of the grape-berry moth, North East, Pa., 1907.*

Date of emergence.	Number of moths.	Date of emergence.	Number of moths.	Date of emergence.	Number of moths.	Date of emergence.	Number of moths.
Aug. 17	56	Aug. 26	105	Sept. 1	22	Sept. 9	39
19	5	27	33	2	13	11	19
20	29	28	38	3	7	14	3
21	70	29	60	4	11		
22	34	30	36	5	22	Total.	695
24	57	31	28				

Figure 13 gives a graphic representation of the rate of emergence of the moths of the first brood for the season of 1907.

The most extensive record of the egg stage of the second brood was secured in the season of 1907. Table XVIII gives the length of this stage for 35 eggs, which shows an average of 6.5 days, the

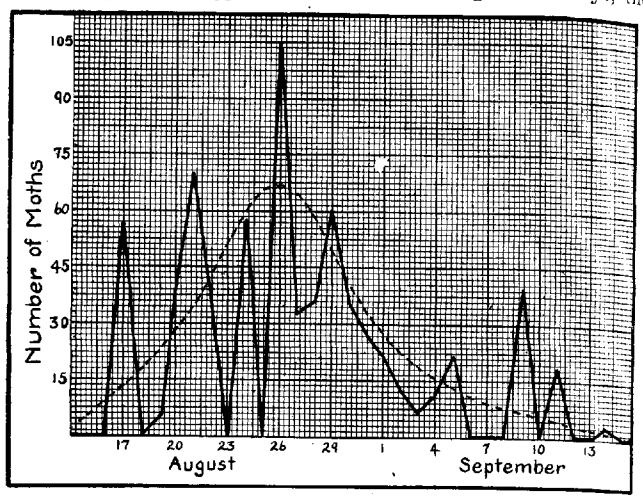


FIG. 13.—Diagram showing the time of emergence of the first-brood moths of the grape-berry moth in 1907, at North East, Pa. (Original.)

minimum being 5 days and the maximum 9 days. This record shows a shorter period than that secured for a smaller number of eggs in 1909 (see Table XII, which shows an average of 10.1 days, a minimum of 9 days, and a maximum of 11 days).

TABLE XVIII.—*Length of incubation of second-brood eggs of the grape-berry moth, North East, Pa., 1907.*

No. of observation.	Date—		Days of incubation.	No. of observation.	Date—		Days of incubation.	No. of observation.	Date—		Days of incubation.
	Laid.	Hatched.			Laid.	Hatched.			Laid.	Hatched.	
1	Aug. 31	Sept. 6	6	14	Sept. 1	Sept. 9	8	27	Sept. 10	Sept. 16	6
2	...do....	...do....	6	15	...do....	...do....	8	28	...do....	Sept. 17	7
3	...do....	...do....	6	16	...do....	...do....	8	29	Sept. 11	Sept. 16	5
4	...do....	...do....	6	17	...do....	...do....	8	30	...do....	Sept. 17	6
5	...do....	Sept. 7	7	18	Sept. 10	Sept. 16	6	31	...do....	...do....	6
6	...do....	...do....	7	19	...do....	...do....	6	32	Sept. 12	...do....	4
7	...do....	...do....	7	20	...do....	...do....	6	33	...do....	...do....	5
8	...do....	...do....	7	21	...do....	...do....	6	34	...do....	...do....	5
9	...do....	...do....	7	22	...do....	...do....	6	35	...do....	Sept. 18	6
10	...do....	Sept. 8	8	23	...do....	...do....	6				
11	...do....	...do....	8	24	...do....	...do....	6		Average.....		6.5
12	...do....	...do....	8	25	...do....	...do....	6		Maximum...		8
13	Sept. 1	Sept. 9	8	26	...do....	...do....	6		Minimum....		5

Table XIX gives the emergence record of 279 moths of the spring brood for the season of 1908. There is a variation of several days in the dates of the maximum emergence of the moths for the three seasons, the maximum emergence being nearly a week earlier in 1908 than in 1907 and 1909. In each instance, however, the period of maximum emergence of the moths coincided quite closely with the period of full bloom of the grape.

TABLE XIX.—*Time of emergence of moths of the grape-berry moth in the spring of 1908, North East, Pa.*

Date of emergence.	Number of moths.	Date of emergence.	Number of moths.	Date of emergence.	Number of moths.	Date of emergence.	Number of moths.
June 1	6	June 19	15	July 3	3	July 15	1
June 7	5	June 20	15	July 5	1	July 16	1
June 8	17	June 21	1	July 6	2	July 17	1
June 9	7	June 22	7	July 8	1	July 19	1
June 10	12	June 23	8	July 9	1	July 20	2
June 12	16	June 24	9	July 10	1	July 22	1
June 13	30	June 25	4	July 11	1	July 23	2
June 15	14	June 26	3	July 12	1	July 25	1
June 16	22	June 29	11	July 13	1		
June 17	17	July 1	1	July 14	4	Total.	279
June 18	33						

Figure 14 gives a graphic description of the rate of emergence of the spring brood of moths for 1908, showing that the maximum number of moths emerged after June 13—about the date that grapes normally commence to blossom.

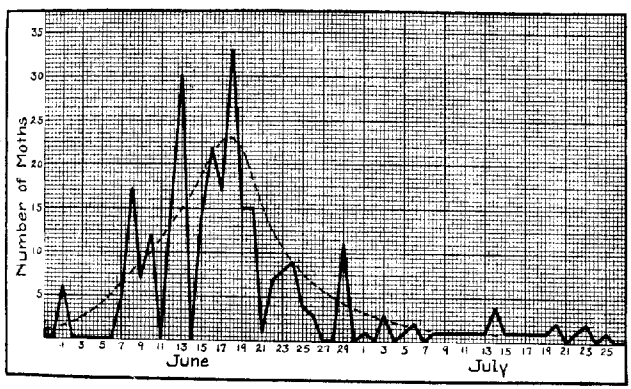


FIG. 14.—Diagram showing the time of emergence of the spring-brood moths of the grape-berry moth in 1908, at North East, Pa. (Original.)

The first record of oviposition in 1908 was made of eggs found in very small berries in rearing cages June 17. No record of the egg stage of the first brood was secured, on account of great difficulty in getting moths to oviposit in confinement. The larval period

of one specimen of the first brood in 1908 was secured. This larva hatched June 20. It emerged from fruit and started to make its pupal case July 10, and had transformed to pupa by July 12, making the larval stage 22 days in length. This period coincides quite closely with the average larval period secured for several larvæ of the first brood during the season of 1909, which was 21.25 days.

The earliest record of emergence of first-brood moths was made on July 13 from a pupa found July 1 on a leaf in the rearing cage in 1908. This is 10 days earlier than the record for other moths from the same source (see Table XX). The emergence record in this table is doubtless somewhat abnormally early, owing to the fact that the temperature in the rearing cage was several degrees higher than outside.

TABLE XX.—*Time of emergence of first-brood moths of the grape-berry moth, North East, Pa., 1908.*

Date of emergence.	Number of moths.	Date of emergence.	Number of moths.	Date of emergence.	Number of moths.	Date of emergence.	Number of moths.
July 23	3	July 26	26	July 29	4	Aug. 1	1
July 24	4	July 27	31	July 30	2		
July 25	8	July 28	9	July 31	3	Total	91

SUMMARY OF LIFE-HISTORY STUDIES OF THE GRAPE-BERRY MOTH.

Life-history studies of this pest at North East, Pa., during the seasons of 1907, 1908, and 1909 indicate that there is only one full brood of larvæ and a partial second brood each year in the vineyards of the Lake Erie Valley. The partial second brood of larvæ, however, is larger in numbers than the full first brood, probably on account of the large number of fatalities that occur among the pupæ during the winter season which tends materially to lessen the number of moths that emerge in the spring. The moths from overwintering pupæ commence to emerge about June 1. (See fig. 15, with curve showing length of the various stages of the grape-berry moth for the season of 1909.) Less than 25 per cent of these spring-emerging moths appear before the grape is in full bloom. The total emergence period of the spring moths is about 60 days. As the period of maximum emergence is from June 10 to July 10, it overlaps into the emergence period of the first brood. About 4 to 6 days elapse between the emergence of the moths and the deposition of eggs. The egg stage of the first brood covers about 6 days. The larval period covers about 23 days and the pupal stage about 13 days. A small percentage of the pupæ of this first brood pass the winter. The moths of the first brood commence to emerge during the latter part of July, the maximum number emerging from about August 10 to September 1. The period of incubation of the second-brood eggs is a little longer than

that of the first brood. (See Tables IV and XII.) The larval stage of this brood is also longer than that of the first brood, the average being 22 days for the first brood of larvæ as against 40 days for the larvæ of the second brood. The larvæ of the second brood commence to leave the fruit about the middle of September. The maximum number of larvæ leave the fruit during the last week in September and the first 10 days in October. By October 15 the number of larvæ found in the fruit upon the vines is very small. By this date practically all of them have dropped to the ground and formed pupal cases on the small percentage of grape leaves that have fallen prematurely from the vines. Rarely is a pupal case of this second brood found on the leaves attached to the vines. On

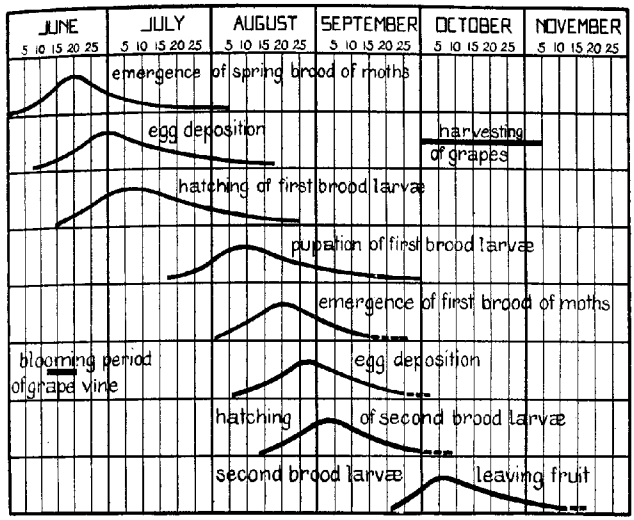


FIG. 15.—Seasonal history of the grape-berry moth as observed in 1909, at North East, Pa. (Original.)

the moist leaves on the ground beneath the vines the second-brood larvæ and also a small percentage of the first brood make their cocoons and pass the winter as pupæ.

PARASITIC ENEMIES.

Detailed studies of the habits and life history of the grape-berry moth during the past few years have shown that this insect is beset with a large number of hymenopterous parasites. Previous to the study of the habits of this pest made by Prof. M. V. Slingerland in the vineyards of Chautauqua County, N. Y., the only record of attack by parasites found in the literature on this subject is made by Dr. C. V. Riley in 1869. Two maggots were found by him destroying

the larvæ of the grape-berry moth, but he failed to rear the adult parasites from them.

During his studies of this insect covering the seasons of 1903 and 1904, Prof. Slingerland reared six different kinds of parasites of the grape-berry moth, which he considered an unusually large number. Four of these were ichneumonids and two were braconids. These rearings by Prof. Slingerland are quoted as follows:[1]

Bracon scrutator Say. (Boston Journ. Nat. Hist., I, 254). The maggot of this little Braconid parasite seems to feed externally on the nearly full-grown caterpillars of the second brood at work in the green fruit in August. Their little, white cocoons are spun in the infested berries. The adults emerged in about two weeks on the following dates: Aug. 28, Sept. 1, 4, and 10.

Bathymetis sp. near *terminalis* Ashm. We reared two females of this comparatively large parasite from hibernated pupæ on May 31. The grape-berry moth caterpillar

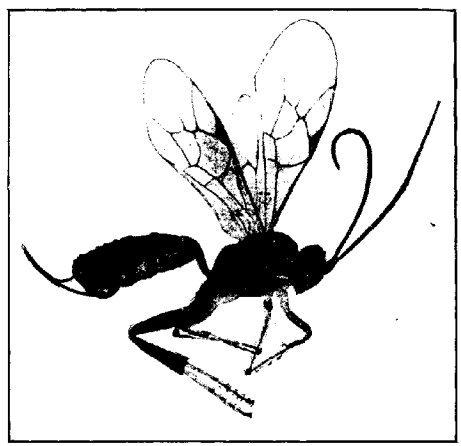


FIG. 16.—*Thymaris slingerlandana*, a common parasite of the grape-berry moth. Enlarged. (After Slingerland.)

had pupated and the parasite's cocoon filled that of its host. Dr. Ashmead reports our specimens as probably undescribed, but possibly *terminalis*, which was described from a male only.

Glypta animosa Cress. (Trans. Am. Ent. Soc., III, 154). One specimen of this Ichneumon emerged from an over-wintered cocoon on June 4. It spun a very thin cocoon and had evidently killed the caterpillar, as no trace of a pupa was found. The recorded hosts of this parasite are *Pædisca scudderiana*, two other Tortricids and a Pyralid.

Glypta vulgaris Cress. (Trans. Am. Ent. Soc., III, 157). Two specimens of this common parasite emerged on August 25 and 27 from thin, white cocoons nearly filling their host's cocoon in a wild grape. Like *Glypta animosa*, this species evidently kills the caterpillar, but it works on the summer brood. It is also parasitic on a species of *Gelechia* and on a Pyralid (*Margaronia quadristigmalis*).

[1] Bul. 223, Cornell Univ. Agr. Exp. Sta., pp. 52-53, 1904.

Urogaster [=*Apanteles*] *canarsiæ* Ashm. (Ent. Soc. Wash., IV, 127, with figure). Found the cocoons of this probable parasite in the webbed blossoms where grape-berry moth caterpillars had worked. Two specimens emerged on July 3 and 7. Its other known host is the Pyralid (*Canarsia hammondi*).

Thymaris slingerlandana Ashm. [fig. 16] (Can. Ent., XXXVI, Nov., p. 333). From August 15 to 27, we reared 17 specimens of this little black Ichneumon with orange-colored, light yellow-banded legs from the cocoons of the grape-berry moths working in both wild and cultivated grapes. Its cocoon occupies about half the space inside the host's cocoon, and evidently the caterpillar was its victim.

In the miscellaneous rearings of the different stages of the grape-berry moth made at the field laboratory of the Bureau of Entomology at North East, Pa., from 1906 to 1911, in connection with life-history studies, together with parasitized specimens observed and collected in the vineyards, 12 additional hymenopterous parasites of different species have been recorded as preying upon this insect. This makes a total list of 17 different parasites known to prey upon this vineyard pest in the Lake Erie Valley at some stage or other of its life cycle. This is a long list of natural enemies for an insect. These parasites are doubtless an important factor in reducing the numbers of the grape-berry moth and their occurrence may explain to some extent the fluctuations in its numbers which occur from year to year.

In the rearing work conducted at North East, Pa., all of the adult parasites emerged from jars containing either larvæ or pupæ of the grape-berry moth during the period between July 12 and September 14. No parasites were collected in the early spring from overwintering cocoons, although a large amount of this material was carried over the winter of 1908 for the purpose of making life-history studies during the season of 1909. This would indicate that parasitism is most active upon the developing first brood of larvæ and pupæ about the period at which this brood exists in the greatest numbers. It would seem, therefore, that the great activity of these parasites during this period must be an important factor in curtailing the second brood of grape-berry moth larvæ that is so destructive to the grape berries at the approach of the ripening season.

Five of the parasites reared were braconids, seven were ichneumonids, all reared from larvæ and pupæ, and one, a chalcidid, reared from the eggs of the grape-berry moth. All of the parasites with the exception of the egg parasites were determined by Mr. H. L. Viereck, of the Bureau of Entomology. Their names are given in Table XXI, which also gives the date of their emergence, the stage of the host, the number reared, and the other host insects from which they have been previously recorded.

TABLE XXI.—*Parasites reared from the grape-berry moth (Polycrosis viteana) feeding upon the fruit of wild and cultivated grapes at North East, Pa., 1906–1911.*

Family.	Date of emergence.	Stage of host.	Number of specimens reared.	Previously recorded hosts.
BRACONIDÆ.				
Microbracon mellitor Say	Aug. 6–19, 1909	Larva	15	Many species of Coleoptera and Lepidoptera.
Microbracon dorsator Say	Aug. 3–Sept. 1, 1911	do	9	Do.
Apanteles sp	Aug. 12, 1911	do	1	No record.
Ascogaster carpocapsæ Vier	Aug. 14, 1911	Pupa	4	Carpocapsa pomonella.
Meteorus sp	Aug. 9, 1909	Larva or pupa.	1	No record.
ICHNEUMONIDÆ.				
Phytodietus sp	July 13, 1906	Larva	1	Do.
Epiurus indagator var. nigrifrons Vier.	Aug. 5, 1911	do	2	Do.
Orthizæma sp	July 13, 1908	do	1	Do.
	Sept. 13, 1907	do	2	
Omorgus nolæ Ashm. race	Aug. 16–22, 1909	do	2	Nola sp., a pyralid.
Dioctes obliteratus Cress	July 13, 1906	Pupa	1	Gelechia rubidella.
Dioctes obliteratus Cress	July 21, 1907	do	2	Do.
Dioctes obliteratus Cress	July 22, 1908	do	1	
Dioctes obliteratus Cress	Aug. 2–27, 1909	do	27	Do.
Dioctes obliteratus Cress	Aug. 2–27, 1911	do	21	Do.
Ameloctonus sp	Aug. 24, 1909	do	3	No record.
Itoplectis conquisitor Say	Aug. 3, 1911	do	2	Many species of tortricids, noctuids, bombycids, and tineids.

In glancing over this table it will be observed that the parasite reared in greatest numbers from the grape-berry moth was *Dioctes obliteratus* Cress. Mr. Viereck states that the supposedly new species reared by Prof. Slingerland in 1904 and named by Dr. William H. Ashmead [1] as *Thymaris slingerlandana* Ashm. (see fig. 16) is the same as *Dioctes obliteratus* Cress. The largest number of parasite specimens reared by Prof. Slingerland belonged to this species; hence it is very probable that it is quite widely disseminated throughout the vineyards of the Chautauqua County grape belt wherever the grape-berry moth abounds, and is perhaps the most effective enemy of the grape-berry moth of all of the parasites mentioned in this list.

In addition to the parasites previously mentioned as attacking the larvæ and pupæ, on September 7, 1906, a large number of parasitized eggs of the grape-berry moth were found in a badly infested portion of the vineyard of Mr. W. S. Wheeler at North East, Pa. A number of adults were reared from these parasitized eggs and later identified by Dr. Howard as *Trichogramma pretiosa* Riley. This is the first record of parasitized eggs of this insect that has come to our notice, and it is the only instance in which this condition has been observed during this investigation.

[1] Can. Ent., vol. 36, pp. 333–334, November, 1904.

DEGREE OF VINEYARD INFESTATION IN ERIE COUNTY, PA.

The infestation of vineyards by this pest is by no means general. It frequently happens that serious infestation will be confined to one or two rows along the edge of a vineyard or running in for a few vines at the end of a number of rows, or again, in an irregular patch at the corner of a vineyard. Usually such areas of very serious infestation are adjoining hedgerows, fences, or bordering rough lands which admit of the accumulation of leaves and trash. On the other hand, the worst infestation over a large area coming under our observation was in a vineyard which was surrounded by neither hedges nor ditches, was a considerable distance from woodlots or rough land, and was subject to clean culture and excellent care. Again, it is not unusual to find a vineyard portions of which have been badly infested for a number of seasons but adjacent vineyards comparatively free from infestation. Because of this seemingly erratic infestation it is exceedingly difficult either to estimate the actual damage wrought by the pest or to secure reliable results for comparison as to the amount of benefit from remedial treatment. Another result of this erratic infestation is that the vineyardist will minimize the extent of the injury or even entirely overlook it until picking time, when he is astonished to discover the large amount of damage that has been done. When this abundant evidence of injury is brought so clearly to his attention at picking time he is likely to make a vow to take some steps toward the eradication of the pest next season, but only too often, unless the first brood is extremely abundant, the period for effective treatment is again permitted to slip past and the extent of injury at picking time is likely to be the same as in previous years. An additional result of this somewhat restricted and local infestation is that methods of control of the pest are not so freely discussed among the vineyardists and there is not the impetus of a general effort to effect its control that there is in the endeavor to combat an insect whose injury is more apparent and widespread, as in the case of the grape rootworm and the grape leafhopper.

The statements dealing with the destructiveness of this insect in the preceding paragraphs apply to the depredations of the pest in the vineyards of the Lake Erie grape belt, where local conditions have been studied closely for several seasons. In the township of North East, Pa., there is an area stretching east of the town to the New York State line and lying south of the Lake Shore Railroad in which are located the vineyards most heavily infested by the grape-berry moth in this region. In the summer of 1906 one large vineyard was visited in this area in which the infestation was quite general and on limited portions of it the fruit was almost unmarketable.

The infested clusters shown in Plate VI, figures 1–2, were taken from this vineyard. In not all of the vineyards in this area is serious infestation so general. In some of them serious infestation is quite local and in others the injury is almost negligible. Outside of this area infestation in vineyards in Erie County, Pa., is more or less local. Yet the insect is always present in sufficient numbers to become a menace at any time that natural conditions favor its rapid increase, and at the present time the insect is responsible for a greater shrinkage in crop yield than most vineyardists are aware.

REMEDIAL MEASURES.

Several methods for the control of the larvæ of the grape-berry moth have been recommended, namely, the destruction of fallen leaves, plowing the vineyard late in the fall or very early in the spring, bagging the clusters, picking the infested berries, removal of infested berries from the vineyard during the harvesting season, and the use of poison sprays.

THE DESTRUCTION OF FALLEN LEAVES.

Since the larvæ of the second brood on leaving the ripening fruit make their cocoons upon the leaves of the grapevine, the destruction of the fallen leaves has been frequently recommended as a means of control. Until within recent years, however, it was not known that practically all of the overwintering larvæ, on leaving the fruit, instead of forming their cocoons upon the grape leaves attached to the vines, drop to the ground and form their hibernating cocoons on the small percentage of prematurely fallen leaves. Observations on the hibernation habits of this insect in infested vineyards at North East, Pa., in the fall of 1906, showed that practically all of the larvæ had emerged from the fruit by the end of the first week in October and that all of the larvæ and pupæ found at that date were in the cocoons made on leaves upon the ground directly beneath the trellis. In practically all cases the leaves upon which these cocoons were made were in close contact with the soil and in a more or less sodden condition, either from moisture absorbed from the soil or as a result of the fall rains. Many leaves bearing cocoons were plastered to the ground as a result of beating rains and even at this early date were in such a state of semidecay that in attempting to gather the leaves they sometimes fell to pieces in much the same manner that a rainsoaked sheet of newspaper will do under the same conditions.

Although hundreds of cocoons were found on these moist leaves upon the ground only one cocoon was found upon the leaves still attached to the vines, and this was imperfectly formed. Practically all of the fruit on the vines examined during the first week in October had been recently infested and was still hanging upon the vines in close contact with the foliage. These observations confirm those

made by Prof. H. A. Gossard in Ohio during the same season. Searches in badly infested vineyards every season since 1906 have shown a similar condition. This habit of the larvæ may be due to the fact that at this season the leaves upon the vines are somewhat withered and brittle. Hence it would appear to be more difficult for the larvæ to fold the flap of the portion of the leaf cut out for making the cocoon, whereas, when the leaves have fallen to the ground and have absorbed moisture from the soil they are less brittle and the flap can be folded much more readily. Whether this is the true cause of the larvæ seeking the leaves on the ground upon which to form their overwintering cocoons or not the fact that they do so has an important bearing upon the practice of destroying fallen leaves as a means of destroying the overwintering pupæ. Since most of the cocoons are made upon a small number of leaves which are stuck more or less firmly to the ground there is little likelihood that many of them will be blown into piles in the corners of vineyards or into hedgerows as has been supposed. Unless these infested leaves are gathered carefully before the period of soaking rains during the late fall and winter they are likely to fall apart and leave the cocoons containing the pupæ in the vineyard. Perhaps an attempt to gather these infested leaves from the ground beneath the trellis during the middle or latter part of October, before the remainder of the leaves have fallen from the vines, would prove more effective than to try to destroy all of the leaves at a later date. There is no doubt that large numbers of pupæ can be collected in this way over limited areas where the infestation is heavy. Unfortunately, however, the vineyardist is too busily engaged in harvesting his grape crop at this time to adopt this method of control.

PLOWING IN LATE FALL OR EARLY SPRING.

Since it is evident that few of the infested leaves are likely to be removed by the winds from the ground beneath the trellis it is quite possible that large numbers of them could be destroyed by plowing the badly infested portion of the vineyards immediately after the crop of grapes is harvested and before the rest of the leaves have fallen from the vines. Plowing at this time would be more likely to insure the covering of the infested leaves than if all of the leaves had fallen, for then the loose leaves would be likely to drive ahead of the plow and force some of the infested leaves to the surface.

Many vineyardists object to fall plowing of vineyards, and, where it is impracticable, early spring plowing is suggested. Care should be taken to throw the soil well under the trellis so that all of the leaves may be covered. Since only a small percentage of the moths emerge before June 1, plowing up to the trellis during the month of May would doubtless cover many of the pupæ.

BAGGING THE CLUSTERS.

In some parts of New York State the fruit on many acres of Niagara grapevines is protected by inclosing each cluster in a paper bag immediately after blossoming. The bagging of clusters of this variety is done primarily for protection against rot. This method of control, however, involves considerable expense and while very effective can not be employed as a means of protection except on choice table varieties, and hence will not appeal to the large producers of grapes for wine or grape-juice purposes.

HAND PICKING INFESTED BERRIES.

By hand picking the infested berries from the clusters in July and early August the size of the second brood may be greatly reduced. The infested green berries are made conspicuous by the presence of a purple spot at the point of entrance of the larvæ. Sometimes the berry cracks open and again several small berries may be tied together by a silken web (see Pl. V, fig. 2). Before the berries in the cluster are large enough to touch each other the infested berries may be readily discerned, but at a later date it is necessary either to handle each cluster or to examine the fruit from both sides of the trellis. The infested berries collected in this way should be removed from the vineyard and the larvæ destroyed. This may be done by immersing the berries in a kettle of boiling water or burying them beneath several inches of soil.

REMOVAL OF "TRIMMINGS."

During the past few years it has become a common practice to pick and pack the fruit in baskets in the vineyard. In this case the "wormy" berries are removed from the clusters and allowed to fall to the ground and thus the larvæ infesting them remain in the vineyard to infest the crop during the next season. A better method which is practiced by some vineyardists is to have each picker carry an extra basket into which these infested "trimmings" can be placed and be removed from the vineyard and destroyed. If the badly infested portions of vineyards are harvested at the very opening of the picking season many larvæ can be destroyed in this way. At a later date in the harvesting season this removal of the worm-injured berries from the vineyard will not be very effective, for, as previously explained, practically all of the larvæ have then left the fruit.

EXPERIMENTS WITH POISON SPRAYS.

VINEYARD EXPERIMENTS WITH POISON SPRAYS IN 1907.

In the spring of 1907 an experiment was undertaken in the vineyard of Mr. W. S. Wheeler at North East, Pa. (see fig. 17). In 1906 and for several seasons previous the fruit in sections of the vineyard in which this experiment was conducted had been very badly infested by this insect.

The sections were laid off in seven plats of approximately 1 acre each. There were five rows of vines in each plat. (See plan of plat arrangement, fig. 18; dotted lines in figure indicate divisions of plats.)

The insecticides in all cases were applied with Bordeaux mixture since it is desirable to use this fungicide at the time the applications

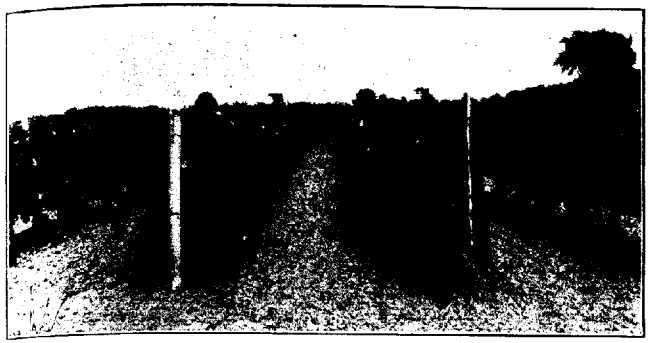


FIG. 17.—Vineyard in which poison-spray experiments were conducted against larvæ of the grape-berry moth during the seasons of 1907, 1908, and 1909; vineyard of Mr. W. S. Wheeler, North East, Pa. (Original.)

are made against the larvæ of the grape-berry moth, to control fungous diseases, such as black rot and mildew. In all cases where arsenate of lead was used the Bordeaux formula was 5 pounds of lime and 5 pounds of copper sulphate to 50 gallons of water. Where arsenite of lime was used with the Bordeaux an additional pound of lime was used to counteract any free arsenic which might be present.

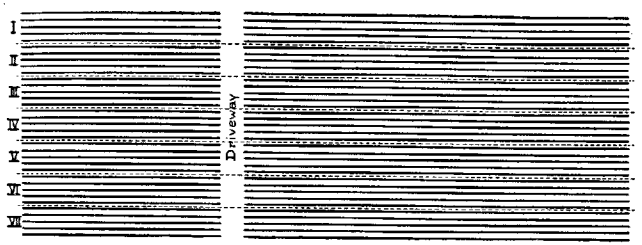


FIG. 18.—Plat arrangement of poison-spraying experiments against the larvæ of the grape-berry moth in the vineyard of Mr. W. S. Wheeler, North East, Pa., 1907. (Original.)

A gasoline-engine vineyard sprayer outfit (fig. 19) was used for making the application.

The spray was applied to the vines from the machine by means of a fixed-nozzle arrangement (see fig. 19). To a vertical rod on both sides of the back end of the machine two short spurs of $\frac{1}{4}$-inch pipe are attached. Each spur carries a large nozzle of the cyclone type from which the spray is discharged into the side of the vine on the trellis.

A third and upper nozzle is mounted on a longer spur which projects over the trellis. This nozzle is directed downward, throwing the spray upon the topmost growth on the trellis. Such a machine carrying a pressure of 100 pounds and over will force the spray into the vines on the trellis and cover quite thoroughly all of the foliage and fruit clusters, especially during the early part of the season before the foliage has become dense and before the berries in the cluster have become so large that they touch each other.

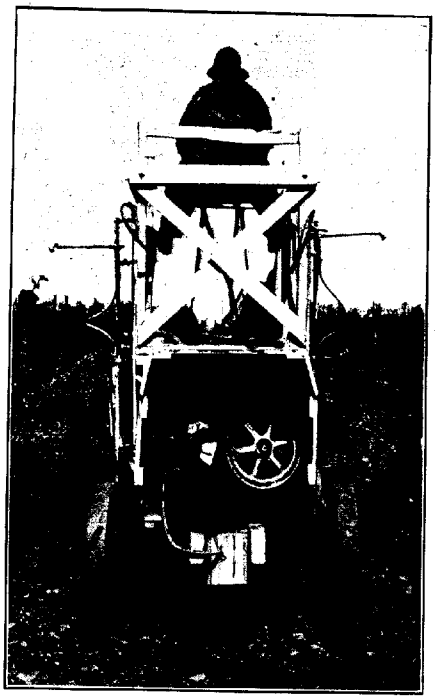


FIG. 19.—Gasoline-engine sprayer outfit used in vineyard experiments against the larvæ of the grape-berry moth in the vineyard of Mr. W. S. Wheeler, North East, Pa., 1907, 1908, and 1909. (Original.)

In this experiment the team was driven slowly down each row so that the vines were sprayed from both sides of the trellis. A pressure of about 100 pounds was maintained and about 100 gallons of spray were applied per acre.

Table XXII gives the spray treatment applied to each plat and also dates of application.

TABLE XXII.—*Spray formulas and dates of application against larvæ of the grape-berry moth. Vineyard of Mr. W. S. Wheeler, North East, Pa., 1907.*

Plat No.	Spray formula.	Number of spray applications.	Date of application.
I.	Three pounds arsenate of lead to 50 gallons of Bordeaux mixture	3	June 19, July 5, 27.
II.	Three pounds arsenate of lead and 2 pounds resin-fish-oil soap to 50 gallons of Bordeaux mixture.	3	Do.
III.	One quart arsenite of lime, Kedzie's formula, and 2 pounds resin-fish-oil soap to 50 gallons of Bordeaux mixture.	3	Do.
IV.	One quart arsenite of lime, Kedzie's formula, to 50 gallons of Bordeaux mixture.	3	Do.
V.	One quart arsenite of lime, Kedzie's formula, and 2 pounds resin-fish-oil soap to 50 gallons of Bordeaux mixture.	2	July 9, 27.
VI.	Unsprayed		
VII.	Three pounds arsenate of lead and 2 pounds resin-fish-oil soap to 50 gallons of Bordeaux mixture.	2	Do.

The variations in the formulas were made to ascertain, if possible, the value of arsenate of lead as against arsenite of lime in the control of this insect. The resin-fish-oil was added on some plats and withheld on others to determine its value as an adhesive in making the spray stick to the grape berries. The variation in number of applications was made to ascertain if applications made before the blossoming of the grape were of greater value than those made after blossoming. The application on June 19 was made when the blossom clusters were well developed, but a few days before actual blossoming (see fig. 20). The application on July 8 was made after blossoming when the berries were about the size of buckshot (Pl. V, fig. 1). At this stage of development the berries stand some distance apart and the spray can be forced through the cluster, so as to cover all of the berries. The application July 27 was made for the purpose of covering the berries to protect them from the entrance of larvæ of the second brood.

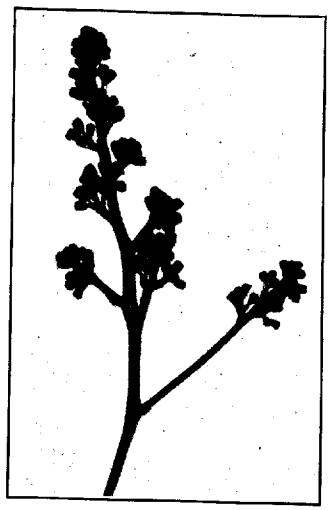


FIG. 20.—Stage of development of grape blossom cluster at which poison-spray application should be made against early hatching larvæ of the grape-berry moth which infest the blossom clusters. (Original.)

In all of these applications the work was quite thorough, and with the exception of the third application most of the clusters were well covered by the spray. When the third application was made the foliage had become rather dense, making it more difficult to reach the clusters, and at the same time the berries had increased in size, forming a somewhat compact cluster. These conditions made it increasingly difficult to force the spray in among the berries. Furthermore, too much poison forced into the clusters in this condition is undesirable, since some of it is likely to be present in the cluster when the fruit is ripe and thus render it undesirable for table use.

During the season four counts were made of infested berries on 25 vines in all of the plats. Table XXIII shows the increase in infestation:

TABLE XXIII.—*Progress of infestation of fruit by larvæ of the grape-berry moth in experimental plats. Vineyard of Mr. W. S. Wheeler, North East, Pa., 1907.*

FIRST COUNT OF INFESTED BERRIES MADE JULY 24.

Plat No.	Date of spray application.	Number of applications.	Spray formula.	Number of vines examined.	Total number of clusters.	Average number of berries per cluster.	Number of infested berries.	Total number of berries counted.	Percentage of berries infested.
I.	June 19, July 8, 27.	3	5-5-3-50.....	25	997	36	205	35,892	0.45
II.	.....do.....	3	5-5-3-2-50.....	25	853	36	83	30,708	.27
III.	.....do.....	3	5-6-1 qt.-2-50.....	25	842	36	113	30,312	.37
IV.	July 9, 27.....	3	5-6-1 qt.-50.....	25	835	36	131	30,060	.43
V.	.....do.....	2	5-6-1 qt.-2-50.....	25	744	36	172	26,784	.64
VI.	Unsprayed.....	None.	None.....	25	890	36	317	32,040	.98
VII.	July 9, 27.....	2	5-5-3-2-50.....	25	1,204	36	126	43,344	.29

SECOND COUNT OF INFESTED BERRIES MADE AUG. 29.

I.	June 19, July 8, 27.	3	5-5-3-50.....	25	997	36	662	35,892	1.84
II.	.....do.....	3	5-5-3-2-50.....	25	853	36	337	30,708	1.09
III.	.....do.....	3	5-6-1 qt.-2-50.....	25	842	36	432	30,312	1.42
IV.	.....do.....	3	5-6-1 qt.-50.....	25	835	36	330	30,060	1.09
V.	July 9, 27.....	2	5-6-1 qt.-2-50.....	25	744	36	419	26,784	1.56
VI.	Unsprayed.....	None.	None.....	25	890	36	696	32,040	2.17
VII.	July 9, 27.....	2	5-5-3-2-50.....	25	1,204	36	340	43,344	.78

THIRD COUNT OF INFESTED BERRIES MADE OCT. 9.

I.	June 19, July 8, 27.	3	5-5-3-50.....	25	997	36	2,326	35,892	6.45
II.	.....do.....	3	5-5-3-2-50.....	25	853	36	1,751	30,708	5.70
III.	.....do.....	3	5-6-1 qt.-2-50.....	25	842	36	1,503	30,312	4.95
IV.	.....do.....	3	5-6-1 qt.-50.....	25	835	36	1,083	30,060	3.60
V.	July 9, 27.....	2	5-6-1 qt.-2-50.....	25	744	36	1,681	26,784	6.27
VI.	Unsprayed.....	None.	None.....	25	890	36	3,549	32,040	11.07
VII.	July 9, 27.....	2	5-5-3-2-50.....	25	1,204	36	1,910	43,344	4.40

FOURTH COUNT OF INFESTED BERRIES MADE OCT. 23.

I.	June 19, July 8, 27.	3	5-5-3-50.....	25	997	36	4,655	27,544	16.90
II.	.....do.....	3	5-5-3-2-50.....	25	853	36	2,295	25,668	9.51
III.	.....do.....	3	5-6-1 qt.-2-50.....	25	842	36	2,648	24,552	10.78
IV.	.....do.....	3	5-6-1 qt.-50.....	25	835	36	2,295	24,232	9.74
V.	July 9, 27.....	2	5-6-1 qt.-2-50.....	25	744	36	2,288	23,562	9.71
VI.	Unsprayed.....	None.	None.....	25	890	36	3,149	23,000	13.69
VII.	July 9, 27.....	2	5-5-3-2-50.....	25	1,204	36	2,338	36,980	6.32

In making these counts it was observed that the infestation was very irregular throughout this block of vineyard. The first two or three rows on Plat I were heavily infested. The fruit on about 20 to 30 vines, on the east end of plats I, II, and III was also quite badly infested. Passing through Plats V, VI, and VII and toward the north side and the west end of the vineyard the infestation was much lighter, and on Plat VII and the extreme west end of Plats IV, V, VI, and VII the infestation was very light. This exceedingly variable condition of infestation has made the tabulation of results very difficult, and it has been quite impossible to bring out the relative value of the different poisons used and the value of the varying number of applications.

The results of the spraying operations for this season are quite indefinite and serve only to bring out the great irregularity in infestation, its progress throughout the season, and the difficulty in laying out a plat arrangement which will show accurately the effect of spray treatment against this pest. That some benefit did result from the spray application is indicated by the fact that in a comparison of infestation in Plats V, VI, and VII, where the infestation was lighter but more uniform than on the opposite side of the vineyard, there was throughout the season a greater infestation on the unsprayed plat than on the two adjacent sprayed plats. There was not sufficient difference in the weight of fruit from the different plats to indicate a commercial value resulting from the use of arsenate of lead as against arsenite of lime.

VINEYARD EXPERIMENTS WITH POISON SPRAYS IN 1908.

The spray work for 1908 was conducted in the same vineyard as in 1907. The plat arrangement, however, was changed. The number

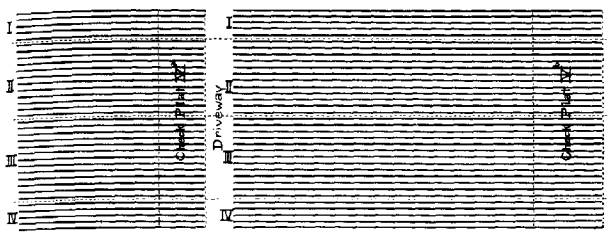


FIG. 21.—Plat arrangement of poison-spraying experiments against the grape-berry moth in the vineyard of Mr. W. S. Wheeler, North East, Pa., 1908 and 1909. (Original.)

of plats was reduced to four. Plat I consisted of 5 rows, Plat II of 12 rows, Plat III of 13 rows, and Plat IV of 5 rows. The position of the check or unsprayed plat was also changed. Checks were left in two places. In the west section 10 vines were left unsprayed on the east end of all the rows of the four plats; in the east section 15 vines were left unsprayed on the east end of all of the rows of the four plats. (See plan of plat arrangement, fig. 21.) The dotted line running across the plats near the east end of both sections indicates the location of the unsprayed check vines; these portions thus separated are numbered Plat V*a* and Plat V*b*, respectively.

This rearrangement of plats was adopted in the hope that the infestation of the vines in these locations would more nearly represent that existing on the sprayed vines.

Arsenite of lime was eliminated from the spray formulas used, on account of slight injury to foliage. The spray formula on all four plats was the same. (See Table XXIV.)

TABLE XXIV.—*Spray formulas and dates of application against larvæ of the grape-berry moth. Vineyard of Mr. W. S. Wheeler, North East, Pa., 1908.*

Plat No.	Spray formula.	Number of spray applications.	Date of application.
I.....	Three pounds arsenate of lead and 2 pounds resin-fish-oil to 50 gallons of Bordeaux mixture.	2	June 4, 18.
II.....	....do.....	3	June 4, 18; July 6.
III.....	....do.....	2	June 19; July 6.
IV.....	....do.....	1	June 19.
V a–b.	Unsprayed.		

The same spraying machine and the same nozzle arrangement were used as in 1907. The pressure maintained was from 100 to 125 pounds. About 100 gallons of spray were applied per acre. The first application was made June 4, just before the blossom buds opened. A double application was made at this date; that is, as soon as the plats had been sprayed once the same plats were gone over again. Only Plats I and II were sprayed at this date. On June 18, just after blossoming, when the berries were about the size of buckshot (Pl. VIII, fig. 1), all four of the plats were given a double spraying. About 100 gallons of spray were used at each application and a pressure of from 100 to 125 pounds was maintained. Plat II received a third application July 6. This also was a double application. In making these double applications the vines were covered very thoroughly by the spray.

As in the previous season the infestation proved to be widely variable, rendering it impossible to make a comparison of the value of the variation in the number of applications made to the different plats. The infestation was distributed in about the same general manner as in the previous year. Plat I, on the south side of the section, was the most heavily infested, the infestation gradually decreasing in the other plats toward the north side of the vineyard. Counts were made on 25 vines in each of the check plats and also in each of the sprayed plats to show the progress of infestation for the first and second broods. (See Table XXV, showing count of infested berries for 1908.)

TABLE XXV.—*Progress of infestation of fruit by larvæ of the grape-berry moth in experimental plats. Vineyard of Mr. W. S. Wheeler, North East, Pa., 1908.*

FIRST COUNT OF INFESTED BERRIES, MADE ON AUGUST 3, 4.

Plat No.	Date of spray application.	Spray formula.	Number of applications.	Number of vines examined.	Number of infested berries.
I.....	June 4, 18.....	5–5–3–2–50.....	2	25	28
II.....	June 4, 18; July 6.....	5–5–3–2–50.....	3	25	15
III.....	June 19; July 6.....	5–5–3–2–50.....	2	25	21
IV.....	June 19.....	5–5–3–2–50.....	1	25	31

TABLE XXV.—*Progress of infestation of fruit by larvæ of the grape-berry moth in experimental plats. Vineyard of Mr. W. S. Wheeler, North East, Pa., 1908*—Continued.

SECOND COUNT OF INFESTED BERRIES, MADE ON SEPTEMBER 24 TO 26.

Plat No.	Date of spray application.	Spray formula.	Number of applications.	Number of vines examined.	Number of infested berries.
I	June 4, 18	5-5-3-2-50	2	25	1,855
II	June 4, 18, 19; July 6	5-5-3-2-50	3	25	1,440
III	July 6,	5-5-3-2-50	2	25	1,095
IV	June 19	5-5-3-2-50	1	25	960

FIRST COUNT OF INFESTED BERRIES MADE ON AUGUST 3, 4.

Plat No.					
V	Unsprayed	None	None.	25	387
I	do	do	None.	25	198
II	do	do	None.	25	153
III	do	do	None.	25	67

SECOND COUNT OF INFESTED BERRIES, MADE ON SEPTEMBER 24 TO 26.

Plat No.					
V	Unsprayed	None	None.	25	4,495
I	do	do	None.	25	2,899
II	do	do	None.	25	2,466
III	do	do	None.	25	1,588

When the fruit was harvested the crop from the sprayed and from the unsprayed plats was weighed. Table XXVI, in the columns under "Yield in pounds of fruit per acre," shows the difference in crop yield per acre on the sprayed and the unsprayed plats. The last column also shows the cash value of the increased yield per acre on the sprayed vines.

TABLE XXVI.—*Amount of fruit infested by the grape-berry moth on sprayed and unsprayed plats and cash value of spray benefit per acre. Vineyard of Mr. W. S. Wheeler, North East, Pa., 1908.*

Plat No.	Date of spray applications.	Number of applications.	Spray formula.	Average number of berries per cluster.	Total number of clusters.	Number of vines examined.
I	June 4, June 18	2	5-5-3-2-50	38	2,312	60
V-I	Unsprayed			38	3,858	60
II	June 4, June 18, July 6.	3	5-5-3-2-50	36	3,371	60
V-II	Unsprayed			36	2,294	60
III	June 19, July 6	2	5-5-3-2-50	36	2,235	60
V-III	Unsprayed			36	1,914	60
IV	June 19	1	5-5-3-2-50	36	1,751	60
V-IV	Unsprayed			36	1,796	60

Plat No.	Total number of berries.	Total number of wormy berries.	Per cent of wormy berries.	Date of examination.	Yield in pounds of fruit per acre.		Cash gain in yield of fruit on sprayed plats per acre (at 1½ cents per pound).
					Sprayed.	Unsprayed.	
I	83,232	4,452	5.3	Sept. 26			
V-I	102,888	11,989	11.6	do	4,175	3,347	$12.42
II	85,464	3,458	4.4	do			
V-II	82,584	7,733	9.2	do	3,826	2,998	12.42
III	80,460	2,632	3.2	do			
V-III	68,904	6,577	9.8	do	3,949	3,010	14.08
IV	63,136	2,309	3.6	do			
V-IV	64,656	4,136	6.3	do	3,186	2,455	10.96

VINEYARD EXPERIMENTS WITH POISON SPRAYS IN 1909.

The spray work for 1909 was conducted in the same vineyard as in 1907 and 1908. The plat arrangement was the same as in 1908. The unsprayed check vines were also in the same location as in 1908. (See fig. 21.) The same gasoline-engine spraying outfit was used as in the two previous seasons and the nozzle arrangement was also the same. A pressure of from 100 to 125 pounds was maintained and about 100 gallons of spray were applied per acre. The first application was made on Plats I and II June 8, just before the blossom buds opened. The second application was made June 28, after blossoming, when the berries were about the size of buckshot. At this date all four plats were sprayed. Plat II was given a double spraying on this date. The other plats received only one application at each date throughout the season. All four plats were sprayed July 9, when the berries were large enough to touch each other in the cluster. (See Table XXVII, showing spray formula and number of applications.)

TABLE XXVII.—*Spray formula and dates of applications against larvæ of the grape-berry moth. Vineyard of Mr. W. S. Wheeler, North East, Pa., 1909.*

Plat No.	Spray formula.	Number of spray applications.	Date of application.
I	Three pounds arsenate of lead to 50 gallons of Bordeaux mixture.	3	June 8, 28; July 9.
II	do	3	Do.
III	do	2	June 28; July 9.
IV	do	2	Do.
Va,–Vb	Unsprayed		

Counts of infested berries were made on 25 vines in each of the unsprayed check plats and also in each of the sprayed plats. (See Table XXVIII, showing progress of infestation for season of 1909.)

TABLE XXVIII.—*Progress of infestation of fruit by larvæ of the grape-berry moth in experimental plats. Vineyard of Mr. W. S. Wheeler, North East, Pa., 1909.*

FIRST COUNT OF INFESTED BERRIES, MADE ON JULY 25.

Plat No.	Date of spray application.	Spray formula.	Number of applications.	Number of vines examined.	Number of infested berries.
I	June 8, 28, July 9	5-5-3-50	3	25	23
II	do	5-5-3-50	3	25	14
III	June 28, July 9	5-5-3-50	2	25	17
IV	do	5-5-3-50	2	25	12

SECOND COUNT OF INFESTED BERRIES, MADE ON SEPTEMBER 21 TO 24.

I	June 8, 28, July 9	5-5-3-50	3	25	750
II	do	5-5-3-50	3	25	306
III	June 28, July 9	5-5-3-50	2	25	550
IV	do	5-5-3-50	2	25	390

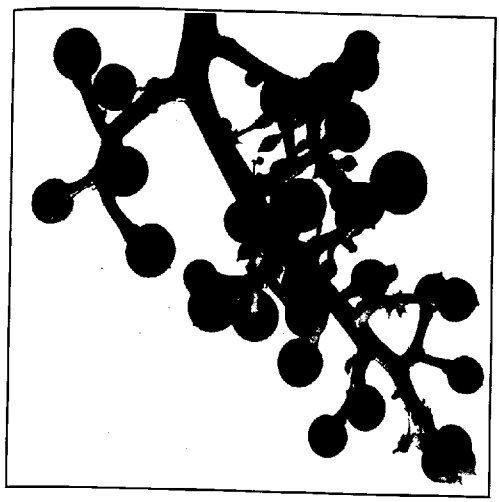


FIG. 1.—SHOWING SIZE OF GRAPE BERRIES AT SECOND SPRAY APPLICATION ABOUT THE TIME MANY OF THE FIRST-BROOD EGGS OF THE GRAPE-BERRY MOTH ARE DEPOSITED ON THEM. (ORIGINAL.)

FIG. 2.—TRAILER METHOD OF VINEYARD SPRAYING IN ORDER TO APPLY THE SPRAY TO THE UNDERSIDE OF THE FOLIAGE OR TO THE GRAPE CLUSTERS WHERE THE FOLIAGE IS DENSE. (ORIGINAL.)

TABLE XXVIII.—*Progress of infestation of fruit by larvæ of the grape-berry moth in experimental plats. Vineyard of Mr. W. S. Wheeler, North East, Pa., 1909.*—Contd.

FIRST COUNT OF INFESTED BERRIES, MADE ON JULY 25.

Plat No.	Date of spray application.	Spray formula.	Number of applications.	Number of vines examined.	Number of infested berries.
Va V	Unsprayed	None	None.	25	34
	do	do	None.	25	28
	do	do	None.	25	21
	do	do	None.	25	19

SECOND COUNT OF INFESTED BERRIES, MADE ON SEPTEMBER 21 TO 24.

Va V	Unsprayed	None	None.	25	1,574
	do	do	None.	25	890
	do	do	None.	25	468
	do	do	None.	25	1,168

The counts were made July 25 and September 21 to 24. The infestation this season, as in 1907 and 1908, was heavier on the south side of Plat I and on the east end of the east section and became lighter toward the north side and west end of the vineyard, a condition which existed throughout the three seasons.

When the crop was harvested it was found that there was practically no difference in weight of fruit per acre on the sprayed and the unsprayed vines. Taking the vineyard as a whole the infestation was very much lighter than in either of the preceding seasons. (See Table XXIX, showing percentage of infected berries on fruit from 25 vines in each of the sprayed and the unsprayed plats.)

TABLE XIX.—*Percentage of grape berries infested by larvæ of the grape-berry moth on 25 vines in sprayed and unsprayed plats. Vineyard of Mr. W. S. Wheeler, North East, Pa., 1909.*

SPRAYED.

Plat No.	Dates sprayed.	Number of times sprayed.	Formula.	Number of vines examined.	Total number of clusters.	Average number of berries per cluster.	Number of infested berries.	Total number of berries.	Percentage of infested berries.	Date clusters were examined.
	1909.									
I	June 8, 28, July 9.	3	5-5-3-50	25	1,512	38	770	57,456	1.30	Sept. 21–24
II	do	3	5-5-3-50	25	1,242	38	396	47,196	.81	Do.
III	June 28, July 9.	2	5-5-3-50	25	1,203	38	554	49,514	1.12	Do.
IV	do	2	5-5-3-50	25	1,288	38	390	48,944	.79	Do.

UNSPRAYED.

Va Vb	Unsprayed	None	None	25	1,102	38	1,574	42,256	3.72	Sept. 21–24
Va Vb	do	do	do	25	994	38	890	37,772	2.36	Do.
Va Vb	do	do	do	25	747	38	468	26,502	1.77	Do.
Va Vb	do	do	do	25	1,182	38	1,168	44,916	2.60	Do.

In considering the results of the spray experiments presented in the foregoing paragraphs the casual reader might infer that the benefit derived does not offset the cost of the operation. Charging the total expense to this particular insect, this would probably hold true for the seasons of 1907 and 1909. The treatment for 1908 shows a cash increase in crop yield, however, which more than offsets the cost of spray treatment for that season. It should be remembered, too, that these spray applications serve to protect the grapevines against the grape rootworm and the fruit and foliage against fungous diseases. For both of these infestations it is desirable to make the spray applications at about the same dates that the applications are recommended to be made for the control of the larvæ of the grape-berry moth. Hence the additional expense involved in the increased amount of spray material used in making applications thorough enough to be effective in decreasing the infestation of the grape berries by this insect is not very great.

The cost of spray material and labor for each application at the rate of about 100 gallons per acre was approximately $2 per acre for each application. Furthermore, there is no doubt that the poison-spray application covering the three seasons greatly reduced the infestation throughout the vineyard, for at the end of the third season's treatment the infestation was manifestly much less than when the experiment was commenced.

RECOMMENDATIONS FOR CONTROL.

At the present state of our knowledge of the habits of this pest and of the methods that have been suggested and employed for its control it is impossible to recommend any one method which of itself has given results that are as satisfactory as could be wished. The life-history studies made during this investigation, which have been discussed under that head, indicate that we have been in error in assuming that there are three broods of this insect in the Lake Erie Valley. According to Prof. Slingerland the first brood develops in the blossom clusters and the recently set berries. The summer or second brood develops on the green grapes during July and early August and a partial third brood occurs in autumn.

On the strength of these statements much emphasis has been placed upon the importance and probable efficiency of a poison spray applied to the vines just previous to blossoming to destroy the larvæ of the first brood which feed upon the blossom cluster. The life-history studies made during this investigation, however, indicate that only about 25 per cent of the spring moths emerge previous and up to the time that the blossom buds break into bloom. Hence no matter how effective this first poison application may be in the destruction of the larvæ actually feeding upon the blossom

clusters it is ineffective against the larger portion of the first brood of larvæ, since at this time only a small portion of them have hatched. On the other hand, it is of great importance to destroy as many as possible of these early appearing larvæ, since the adults into which they develop deposit eggs for the second brood. With our present knowledge that the majority of the larvæ of this first brood do not appear until after the berries have set, this first poison application previous to blossoming can no longer be emphasized as the most important spray treatment, to the extent of regarding later applications as of little value or of withholding them entirely. In fact, with the knowledge that the majority of the larvæ hatch after the blooming period during the first two weeks in July, additional attention should be given to making the spray application very thorough during this period. It is quite probable that a single poison-spray application just before the blossom buds open, followed by a heavy double application about the first week in July just after the berries have set and at a time when the maximum number of larvæ are hatching, will doubtless give the most satisfactory results to be secured from a spray treatment. A study of the experimental results secured in the season of 1908, when this heavy double-application method was followed, indicates that better net results were secured from these double-spray applications than in the seasons of 1907 and 1909, when the plan of making a single application at each date of spraying was followed.

Where these heavy double-spray applications are resorted to it is suggested that a Bordeaux formula consisting of 3 pounds of lime and 3 pounds of copper sulphate to 50 gallons of water be employed instead of 5 pounds of lime and 5 pounds of copper sulphate as is sometimes recommended. The reason for suggesting this weakening of the Bordeaux formula is that injury to the foliage of the grape-vine has been observed to result from very heavy and frequent applications of the stronger formula.

In making spray applications against this insect it is very desirable that a high pressure be maintained in order to force the poison spray into the cluster so that all of the berries may be covered. (See Pl. VIII, fig. 1, showing size of grape berries at date of second spray application, at about the time many of the first-brood eggs of the grape-berry moth are deposited.) If at the second spraying this can not be done with a stationary nozzle arrangement on account of the dense foliage, the trailer method of application used against the grape leafhopper may be employed. (See Pl. VIII, fig. 2.)

When the grape leafhopper is at all numerous in vineyards where spraying treatment for the grape-berry moth is necessary, a combination spray may be used against both insects during the early part of July, using the "trailer" method of application.

Commercial tobacco extracts (blackleaf tobacco extract, containing $2\frac{7}{10}$ per cent nicotine sulphate) applied at a dilution of 1 to 150 gallons of water, or a still more highly concentrated form ('blackleaf 40," containing 40 per cent nicotine sulphate) applied at a dilution of 1 to 1,500 gallons of water, may be used with arsenate of lead. The tobacco extract is used on the leaf as a contact remedy against the nymphs of the grape leafhopper and the arsenate of lead on the fruit against the larvæ of the grape-berry moth. Paris green and arsenite of lime should not be mixed with the tobacco extracts as a substitute for arsenate of lead, for serious foliage injury results from these combinations.

The combination-spray application against these two insects should be made by the "trailer" method, as shown in Plate VIII, figure 2. The nymphs of the grape leafhopper suck the juice from the underside of the grape leaves and are killed by the tobacco extracts coming in contact with their bodies; hence, in making this application to the underside of the grape foliage most of the grape clusters are drenched by the spray. By the addition of arsenate of lead this application may also act as a treatment against the larvæ of the grape-berry moth.

Since no serious infections of black rot have occurred in the vineyards of the Lake Erie Valley during the past few seasons, the stronger fungicide formula does not appear to be necessary. Hence the combination spray formula recommended against this pest is as follows:

Lime	Bordeaux formula	pounds	3
Copper sulphate		do	3
Water		gallons	50
Arsenate of lead (insecticide)		pounds	3

Since the effectiveness of an arsenical spray treatment depends upon the presence of the poison upon the blossom clusters and upon the berries when the larvæ hatch from the eggs and commence to feed upon the blossom buds and berries, and since this period varies more or less each season, it is impossible to give definite dates at which the applications should be made. Hence the development of the blossom clusters and the formation of the berries will doubtless indicate more accurately the hatching period of the larvæ. The following spray schedule is based on the blossoming period of the grape and the development of the berries:

First application just previous to the blossoming period (see fig. 20) to poison the larvæ which feed in the blossom cluster, from about June 8 to 14.

The second application should be made immediately after blossoming, at which time the larvæ commence to feed upon the newly set berries, and the application should be doubled over those portions

of the vineyard where the infestation has been heavy during previous seasons. The time of this second application is approximately from June 20 to 30.

The third application should be made when the berries are about the size of buckshot (see Pl. VIII, fig. 1). If the foliage is dense, the "trailer" method of application should be employed, and if the grape leafhopper is at all numerous the tobacco extract should be added to control the latter insect. The time of this third application is approximately from July 5 to 15.

The poison-spray treatments recommended against the grape root-worm are also covered by the second and third applications against the grape-berry moth.

It should be distinctly understood by the vineyardist that the arsenate of lead is the active killing agent employed against the larvæ of the grape-berry moth and that it is applied with the Bordeaux mixture, which is a fungicide, in order to avoid the duplication of applications.

Where a considerable number of infested grape berries are observed on vineyard areas that received a poison-spray application before the grape blossoms opened, and a heavy double application after the berries had formed, it may be necessary to hand pick the infested berries during the latter part of July before many of the larvæ of the first brood have fully developed. By removing these larvæ from the vineyard and destroying them by immersing the infested berries in boiling water, the amount of infestation by the second brood of larvæ may be greatly reduced.

Should only limited areas of the vineyard prove to be seriously infested at the approach of the picking season, as frequently occurs, it is suggested that the vineyardist remove the fruit from these vines as early as possible, for in doing so he may be able to remove a good many of the larvæ from the vineyard which would otherwise remain there to reinfest the crop of the succeeding season.

In addition to the control methods suggested against the larvæ, special effort should be made to destroy the pupæ which pass the winter in the fallen leaves, on the ground beneath the trellis. (See fig. 22.) As previously mentioned, observations made during this investigation indicate that the majority of the pupæ over-winter in cocoons made upon leaves which have fallen prematurely to the ground beneath the trellis. These leaves are frequently stuck to the soil and are in a state of semidecay before the rest of the foliage has fallen from the vines. Hence there is little likelihood that many of these leaves bearing the cocoons will be blown out of the vineyard. For this reason it is quite probable that if 2 or 3 inches of soil are thrown under the trellis in late fall or early spring many of the pupæ may be destroyed by this operation. It is not known positively that

plowing under the pupa-infested leaves in this manner will destroy the insect in this stage, but it is highly probable that many fatalities will result from the method. It is believed that greater success will result from an endeavor to destroy the pupæ which are in cocoons upon leaves that remain in the vineyard throughout the winter than in the destruction of leaves outside of the vineyard which are blown into fence rows, ditches, and adjacent rough lands. No moths of this insect have been reared from grape leaves gathered from these latter locations, although several attempts have been made to secure specimens from them.

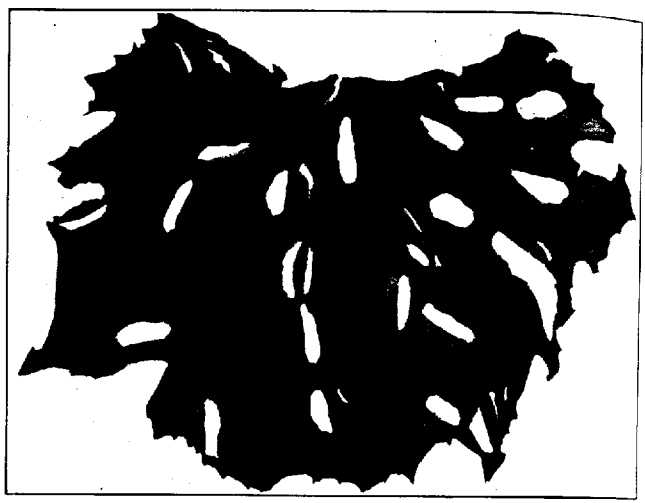


FIG. 22.—Overwintering cocoons of the grape-berry moth upon leaf on ground, beneath a badly infested grapevine. (Original.)

CONCLUSION.

Wherever vineyards have become badly infested by the grape-berry moth serious injury to the crop has resulted and the owners of the infested vineyards have found it a very difficult pest to eradicate. Many vineyardists who have tried to control the pest with a poison spray have not met with as complete success as they would wish. Many such instances of complete or partial failure have been observed. In nearly all of these cases, however, investigation has shown that this lack of success, in all probability, was largely due, either to inferior spraying equipment which failed to deliver the spray in sufficient quantity and force to thoroughly cover the clusters, or to the fact that the applications were not made at a time when the majority of the larvæ were about to hatch. Frequently both of these condi-

tions have occurred simultaneously, and as a result, failure has been complete. For this reason the spray method of control is looked upon with disfavor by many who have carried on the work under these conditions.

In vineyards where infestation is at all serious vineyardists are urged to give the spray method a thorough trial for a period of several consecutive seasons. If the infestation is confined to a limited area, as is frequently the case, the owner can well afford to make additional applications over this area to prevent it from increasing and spreading farther into the vineyard and possibly, at some future time, causing the loss of a large percentage of the crop over the entire area.

A lack of knowledge of the extent of the infestation of his vineyard by this pest during the early stages of the first brood is perhaps one of the chief causes for lack of successful control by the owner. It is hoped that with the aid of the data contained in this paper under "Seasonal history" the vineyardist will be better able to determine the periods when the maximum number of larvæ leave the eggs to enter the berries, and with the additional aid of more efficient high-pressure power-spraying machinery now available for this work it is believed that the poison-spray method of control will prove to be the most effective and practical means of controlling this pest.

Combination spray mixtures, whereby other insect pests of the grapevine can be controlled by the same applications made against the grape-berry moth, have been suggested under the head of recommendations for control and are worthy of trial in the endeavor to reduce the cost of controlling several of the pests that infest the fruit and foliage of the grape in the vineyards throughout the Lake Erie Valley. This phase of control work will receive some attention in connection with further studies to be made of grape pests, by the Bureau of Entomology, in this region.

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Asserts *Polychrosis viteana* does not occur in California.

1910. SMITH, J. B.—Ann. Rept. N. J. State Mus. (1909), with Rept. of N. J. Insects, p. 538.

Sometimes *Polychrosis viteana* causes trouble locally throughout New York. There are three broods. Spraying with arsenate of lead is recommended to kill off the first brood.

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